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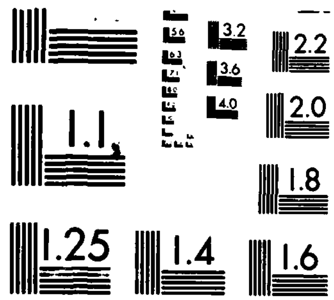

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AIR WAR COLLEGE

RESEARCH REPORT

No. AU-AWC-86-143

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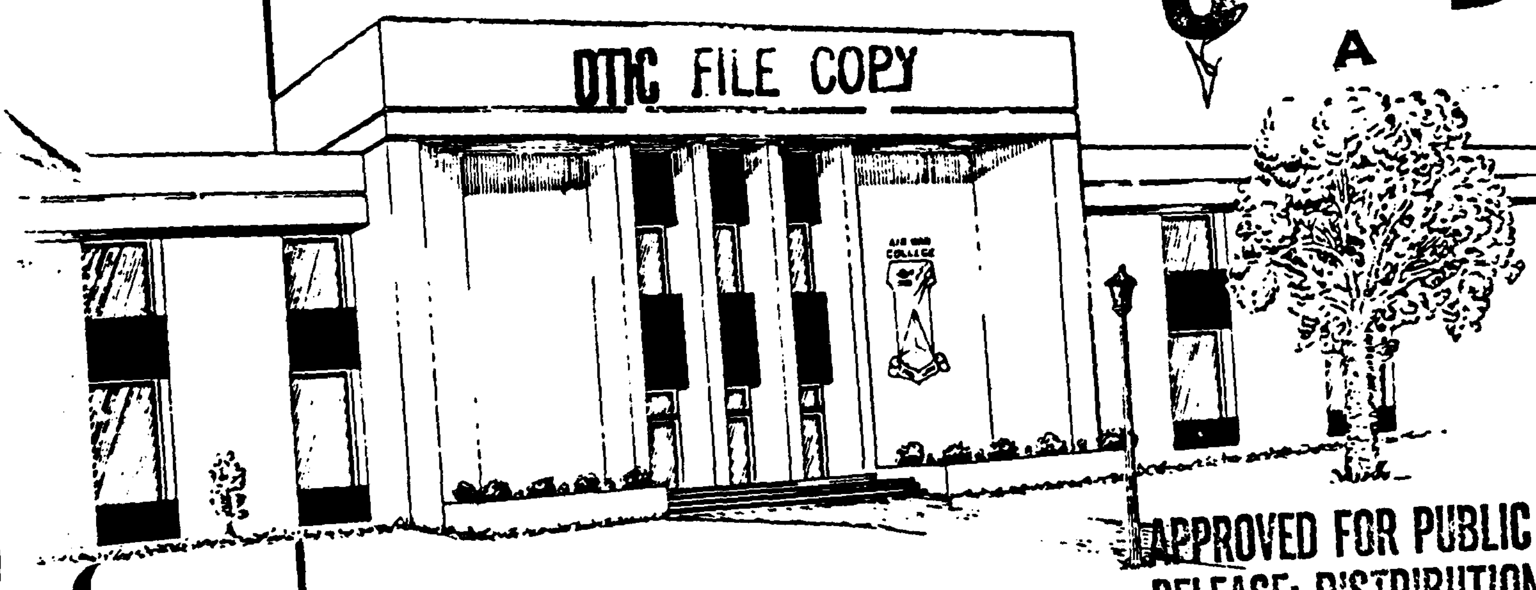
By LT COL JOHN E. MCGEE, CANADIAN AF



AIR UNIVERSITY
UNITED STATES AIR FORCE
MAXWELL AIR FORCE BASE, ALABAMA

AIR WAR COLLEGE
AIR UNIVERSITY

AUGMENTOR WING POWERED LIFT TECHNOLOGY: AFFORDABLE ALTERNATIVES TO ENHANCE TACTICAL AIRLIFT CAPABILITY

by

John E. McGee
Lieutenant-Colonel, CF

A RESEARCH REPORT SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE RESEARCH

REQUIREMENT

Research Advisor: Colonel Glenn T. Caldwell, USAF

MAXWELL AIR FORCE BASE, ALABAMA

MAY 1984

DISCLAIMER-ABSTAINER

This research report represents the views of the author and does not necessarily reflect the official opinion of the Air War College, the Department of the Air Force, or the Canadian Forces.

The author would like to acknowledge the work of Mr. D.C. Whittley, a design engineer with de Havilland Aircraft of Canada Limited and inventor of the augmentor wing and ejector lift concepts, and Mr. A. M. Halkett of the Department of Regional and Industrial Expansion who kept the technological advances before governmental decision-makers. These two proponents of augmentor wing technology recently retired within a month of each other leaving a legacy of achievement, each in his own right, and a well charted course for development.

AIR WAR COLLEGE RESEARCH REPORT ABSTRACT

TITLE: Augmentor Wing Powered Lift Technology: Affordable Alternative to Enhance Tactical Airlift Capability

AUTHOR: John E. McGee, Lieutenant-Colonel, CF

Remarks on the status and capabilities of Augmentor Wing (AW) powered lift technology introduce a discussion of potential Air Force needs satisfaction in a variety of affordable aircraft applications. A description of technology capabilities and cost comparison examples complete the background for the author's view on current and future air force inter and intra-theater tactical airlift operational and program benefits from this technology. Competing technologies and AW applications on Short Take-Off Vertical Land (STOVL) tactical and strategic airlifters and the adaptation of Ejector Lift/Vertical Thrust (EL/VT) technology to an advanced pilot trainer aircraft and a Supersonic Short Take-Off Vertical Land (SSTOVL) fighter, as in the Advanced Tactical Fighter (ATF) and Advanced/Short Take Off Vertical Land (A/STOVL) aircraft are discussed. International development of a joint technology demonstrator and a next generation tactical airlifter to meet United States, Canadian, United Kingdom, West German, French, Australian and other allied requirements is suggested.

BIOGRAPHICAL SKETCH

Lieutenant-Colonel John E. McGee (M.P.A., Auburn University at Montgomery) has been interested in augmentor wing technology applications since his tour in the aircraft requirements directorate of National Defence Headquarters, Ottawa, Canada in 1981. He has discussed the potential for this technology with United States and Canadian government (NASA, USAF, USN, and interested civil departments), and industry representatives as it may be applied to transport, training and fighter aircraft. He commanded 412 (Transport) Squadron in Ottawa from 1978 to 1981. His undergraduate work was in Political Science at Saint Mary's University, Halifax, Nova Scotia, where he was awarded a B.A. (summa cum laude) and the University Gold Medal in Arts. He is a graduate of the Canadian Forces Command and Staff College and the Air War College, Class of 1986.

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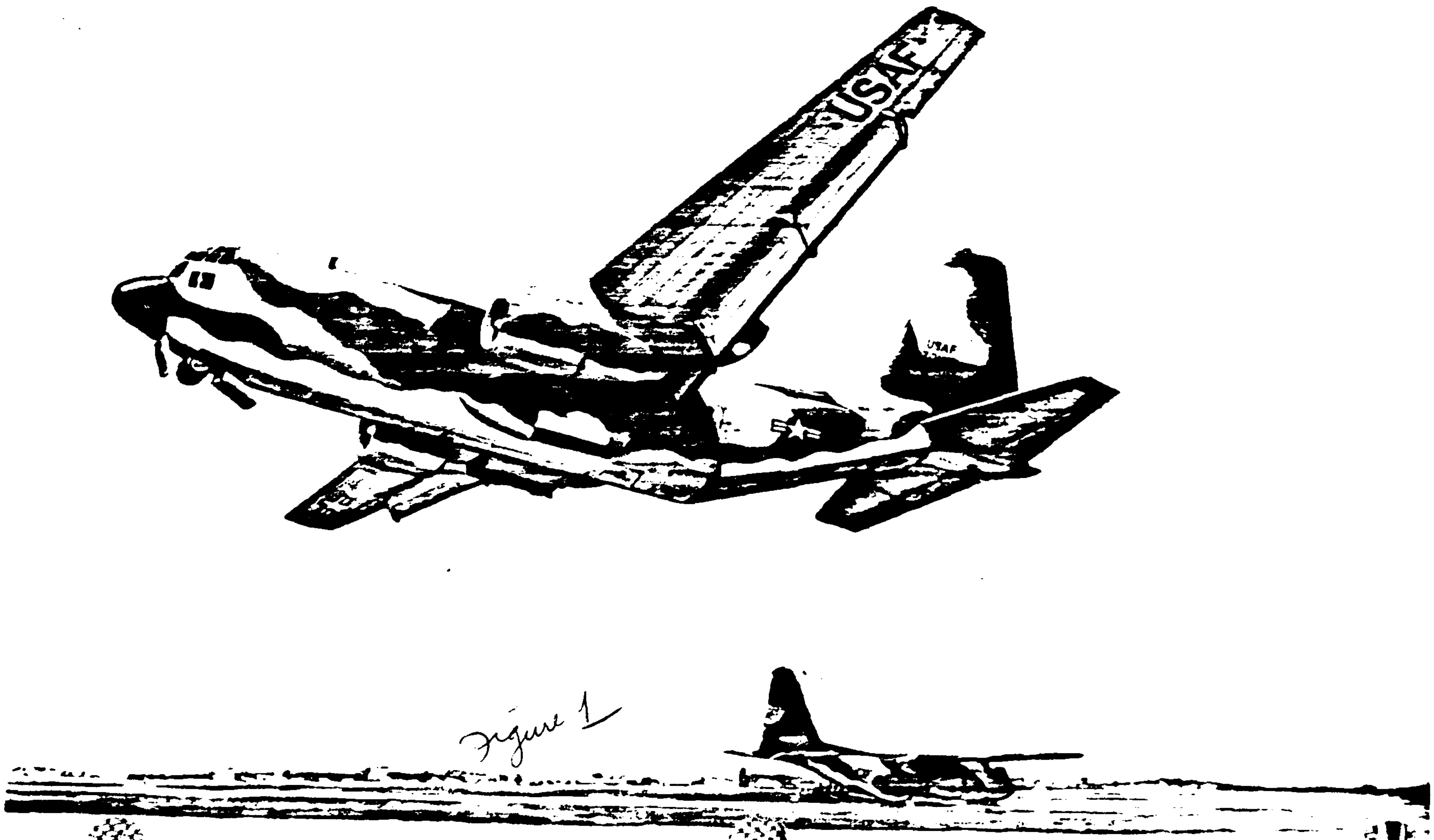


Figure 1

CHAPTER I

INTRODUCTION

The United States Air Force and the Canadian Forces are examining future tactical transport aircraft requirements. A new tactical airlifter will be needed in both air forces near the turn of the century as inventory C-130s approach the end of their economic lives. Even though requirements staffing in both air forces is at preliminary stages, many similarities are already evident. The economies of scale of the larger production run of a joint United States/Canada project would benefit both air forces. Coalition warfare interoperability would also be enhanced through the simultaneous introduction of a common weapons system.

For almost two decades, the Governments of the United States and Canada have been collaborating on engineering, wind-tunnel, and flight research of the De Havilland Canada Augmentor-Wing (AW) technology applied to Short Take-Off and Land (STOL) military transports. The salient features of AW technology when applied to a C-130 would be: faster cruise (M.8), greater payload/range (40,000 lbs, over 4,000 nm), superior STOL field performance, and ease of handling and flight path stability during the loss of the critical engine during STOL landings and takeoffs (the bane of the earlier Advanced Medium STOL Transport [AMST] research aircraft).

The idea for a joint U.S./Canada project to demonstrate these capabilities was conceived in 1983 by Dr. Richard DeLauer, then Undersecretary of Research and Engineering, U.S. Department of

Defense, and is currently on the agenda of The United States/Canada Aerospace Systems Division Task Force. The logic behind Dr. De Lauer's focus on the AW C-130 marriage is clear: the aircraft is currently in production, it approximates the tactical airlifter requirement of most air forces, but needs the enhanced STOL, cruise and payload/range performance, or productivity, of the AW technology. The AW conversion of a C-130 would be affordable. Costs would be approximately the same as re-winging and re-engining the C-130 (not an unimportant factor since the USAF buys its engines for the C-130 on a separate contract from the aircraft itself, and the wings are produced by the Convair Division of General Dynamics.). AW technology is equally applicable to an all-new tactical airlifter designed to maximize performance and productivity gains.

The interests of other nations could also be well served through the application of AW technology to their future tactical airlift needs. The United Kingdom, and Australia have candidate C-130 fleets as do a number of other NATO and third world nations who would appreciate the affordability of the proposal. Since the AW technology is applicable to a variety of proven airframes, it would also be possible to convert the European equivalent of the C-130, the Transall, with the attendant economic, political and military benefits.

The extensive effort which has gone into AW research and analysis has resulted in a technology which is sufficiently mature for development in a variety of tactical airlift applications at low economic and performance risk. The affordability and practicality of AW technology solutions to tactical airlift problems and efforts to support their joint production will be the main focus of this paper.

Joint research is also in progress on a derivative ejector lift technology for a Supersonic Short Take-Off/Vertical Land (SSTOVL) fighter type aircraft. (It was De Havilland Canada's ejector-lift technology which formed the basis of the De Havilland/General Dynamics E-7 SSTOVL research aircraft). In the interest of time, fighter developments, including potential pilot trainer applications, will only be discussed briefly at Chapter VII.

MILITARY AIRLIFT - HISTORICAL INSUFFICIENCY.

Military history is full of examples where the air land or air drop in-theater delivery of troops and war-fighting material was key to success in combat. In World War II, aircraft design and strategy evolved to include not only combat, but combat support[1] in a more comprehensive definition of air power. Recognition of the operational constraints on the delivery, timing and sustainment of combat which is attributable to a lack of military airlift was evident from those early days.[2] The nature and capability of military airlift evolved further during the next forty years as United States and allied forces, variously, fought in, defended, sustained or otherwise participated in the Berlin Airlift, the Suez, the Congo, Israel, Korea, Vietnam, the Falklands and Grenada, for example.

Following World War II, the United States adopted a strategy of deterrence through forward defense requiring continual global resupply of forces permanently stationed outside of the

Continental United States, and the rapid deployment of forces committed to alliances or reacting to threats to vital United States national interests.

> "The people and dollars we devote to defense cannot be employed effectively without efficient processes for the rapid transition from peace to war -- mobilization -- and for the timely movement of forces to the battle field -- deployment. Our ability to mobilize and deploy our forces rapidly is as important to our deterrence strategy as the warfighting capability of the forces themselves.". . . "This strategy serves as a powerful deterrent to aggression. To support it we maintain: . . . -- Projection forces capable of rapidly transporting our active and reserve forces to the location of a conflict."[3]

As the supply-line stretched, airlift capacity, the core of these "projection forces", did not keep pace. In the seventies Army doctrine and modernization were based on larger and heavier vehicles impacting the design of military air transports, and further exacerbating airlift shortfalls qualitatively and quantitatively.

> "The U.S. Army spent a great deal of money in the late 1970s to "heavy up" its divisions, thinking in particular about conditions on the European central front. Now it is enthusiastic about "light infantry," relatively easy to transport to trouble spots. Unfortunately, light divisions are mobile by air transport, but less so once they arrive on the scene, because they have fewer aircraft and vehicles. What approach is the right one? Either. It depends on what you expect to need, and that involves imperfect knowledge and judgement. As usual, the safest is to strike a balance - and do some of each.[4]

Congress directed the Secretary of Defense to define the magnitude of the problem through a study of U.S. military mobility requirements in 1981 which DOD completed that April. In response to defense guidance to provide a minimum level of airlift capabilty, the U.S. Air Force published an Airlift Master Plan in 1983 which defined the size of airlift and the fleet mix, including Initial Operational Capability (IOC) of the C-17 strategic airlifter in 1992.

> "Of particular significance, none of the proposed increases actually satisfied the shortfalls identified. They were merely fiscally realistic goals. For airlift, the recommended objective was an additional capability of 20 million ton-miles per day beyond the 46 million ton-mileage level projected for FY 86. This total of 66 million ton-miles per day has become the accepted goal for U.S. airlift capability."[5]

The 66 million ton miles per day refers to tonnage to be delivered over long (strategic), or intertheater, ranges on C-5, C-141 and C-17 type aircraft.

> "The scenario used in sizing our forces is a worldwide conventional conflict with the Soviet Union and its allies. This scenario severely challenges our mobilization planning and deployment capabilities because it recognizes both the ability of the Warsaw Pact to launch a major attack on NATO with very little warning and the significant advantages the Soviets and their allies enjoy through their proximity to several critical theaters -- Europe, Southwest Asia, and Northeast Asia."[6]

While the important requirement for strategic airlift has not yet been satisfied, planned acquisitions provide a solution by the end of the century when the C-17 program will be completed. As alluded to above, strategic airlift is not the only problem, but it is an important starting point for the discussion of tactical airlift which is the theme of this paper. The troops and materiel to be moved within, or intra-, theater are linked directly to the deployed forces and their sustainment. Thus, a review of the strategic airlift analysis was a prerequisite to the discussion of the next military airlift problem to be solved: a new generation tactical airlifter for the intratheater movement of troops and materiel -- a field currently dominated by the C-130.

Distance is not the dominant factor in intratheater operations and capability is measured in tons per day. The current USAF C-130 fleet can move 9,200 tons per day:[7] a capacity requirment which is unlikely to diminish, thus could be a minimum, or floor, capability level.

The C-130 fleets of the USAF and most of the allies will begin reaching the end of their economic lives in the first decade of the 21st Century. Even so, another 15 to 20 years of operations will tax the ability of air forces to support the earlier model aircraft approaching 30 and 40 years of service in a harsh operating environment.

When the C-130 was developed, its design was subject to ridicule and its success was not anticipated. The design and success of the next generation airlifter cannot be approached in like manner. First, the need for tactical airlift is too great to be left to such chance. Second, the cost of producing a new aircraft dictates a systematic development. As large numbers of this fleet of some 1800 aircraft begin to retire, replacement becomes more practical. Once the C-17 enters the production phase, a new tactical airlifter for the USAF will become budgetarily practicable.

FINANCING AIRLIFT

In spite of the overwhelming need for military airlift, the funding of programs has never been easy. The delay and stretching out of the C-17 program is a case in point. Now, the Gramm-Rudman-Hollings amendment has the potential of imposing automatic spending constraints on DOD which would seriously cut across all defense programs. Military airlift programs are at fragile stages and could be crippled if the Gramm-Rudman-Hollings amendment is triggered. Even if the automatic feature is avoided, DOD is unlikely to enjoy the relatively easy approval of Defense programs of the past five years until the budget deficit is eliminated and the American people are convinced that the threat warrants the expenditure. Secretary Weinberger has eloquently stated the administration's view of the need to sustain a strong defense budget in a recent article in Defense Review:

> "The argument that in meeting the current deficit crisis, fairness requires cuts to be divided equally between defense and domestic programs has a superficial plausability. But consider this proposition. Some of the needs addressed by federal domestic spending can also be met by state governments, local governments, nonprofit enterprises:, business and individuals. But if the U.S. government fails to provide for the nation's defense, no one else can fill the gap. . ."
> "Strength is the price we must pay for peace. Over the past five years, the Congress has appropriated the funds to restore our strength and to secure the peace. If we persist, we now have the prospect of the most far-reaching agreements ever achieved with the Soviet Union to . . . overcome the threat of nuclear annihilation. But such agreements can only be achieved if we negotiate from strength . . . "
> "The choice is ours: we can buy the forces required to secure freedom and peace for ourselves, our allies, our descendants; or we can meanly conclude it is too great an effort, falter and thus yield to the forces of totalitarianism and tyranny."[8]

Notwithstanding the poignancy of the Secretary's assessment, the administration and Congress remain in a classic standoff of foreign and defense versus domestic spending priorities. One conclusion which may be drawn from the economic crunch facing DOD is that the opportunity to enhance operational capability with more affordable programs will be paramount. Thus, the AW technology should realize high priority.

CANADA/UNITED STATES COOPERATION

As a natural consequence of being each other's largest trading partners, there is a strong tradition of industrial and governmental collaboration between the United States and Canada. Canadian Forces modernization in recent years has seen the largest ever peacetime orders placed for American-made aircraft. In fact, ever since the cancellation of its own CF-105 Arrow fighter program in 1958,[9] Canadian military aircraft have almost exclusively been procured from the USA. Still unsatisfied requirements mean substantial future orders remain to be placed. This is certainly the case in tactical airlift where Canada not only has a need for reasonable numbers of aircraft, but has a significant technology contribution to make. Moreover, the Canadian aerospace industry has a solid reputation for building quality components for all of the prime US aerospace manufacturers.[10] A large segment of the Canadian aerospace industry is earmarked to supply the US defense effort within the context of a cooperative North American Defense Industrial Base. Large volumes of work for US forces are undertaken annually through the Defence Development Sharing Agreement. Partners in NORAD and NATO, a partnership in aircraft production is a logical progression of the relationship.

As discussed above, Dr. Richard De Lauer suggested that the Canadian augmentor-wing powered lift technology concept could interest the USAF when applied to the Lockheed C-130 aircraft, at a meeting in Washington in April 1983.[11] Follow-up briefings were given to USAF, USN and NASA[12] officials on September 19, 1983 and again with the USAF in November of that year. In 1984 a USAF team from the Air Force Laboratories at Wright Patterson Air Force Base[13] conducted an audit of the technology and gave it a strong endorsement. As a result of their recommendations for a more modern technology engine, dialogue was initiated with Pratt and Whitney and General Electric. Pratt and Whitney enthusiasm for the project led to their proposal of the PW2037 turbo fan which was briefed to officials in USAF, Systems Command and MAC Headquarters in 1985. Discussions are ongoing among De Havilland, Boeing, Pratt and Whitney and Canadian Government and US Air Force officials to determine how a joint project for a modified C-130 demonstrator might proceed.

President Reagan and Prime Minister Mulroney reaffirmed the Canada/US Defense Development Sharing Agreement and the need to strengthen the North American defense industrial base at their first summit, in Quebec, in March, 1985. In October, 1985, Secretary Weinberger and Defence Minister Nielsen agreed to address, as a matter of priority, the issue of joint participation in major projects. The C-130 Augmentor Wing Powered Lift Demonstrator was specifically identified during their discussions and is being supported by the technical staffs of both countries and the joint Defense Trade Opportunities Task Force.

SUMMARY

Augmentor-wing powered lift technology has the potential to combine conventional fixed-wing aircraft with exceptional short take-off and land field performance while enhancing cruise, payload and range capabilities, and handling characteristics, particularly in the engine-cut case. The technology is sufficiently mature that this can be achieved at low technological and fiscal risk. Related work extends to vertical take-off in transport type aircraft, and in pilot trainers and fighters, using a tilt-wing and ejector-lift and vectored thrust respectively. A range of alternative applications of this technology provide affordable solutions to upgrading the performance of inventory or future design tactical airlifters. The opportunity to reduce the unit cost of any of these solutions exists through joint development and production by the United States and Canada as well as interested allies. Amplification of these views is discussed in succeeding chapters.

CHAPTER I

[1]William H. Tunner. Over the Hump. (Washington, D.C.: Office of Air Force History, 1964). p. viii.

[2]cf General Tunner's shortfall in, Robert F. Futrell. The United States Air Force in Korea 1950-1953. (rev. ed.; Washington, D.C.: Office of Air Force History, 1983), p. 154.

[3]Report of the Secretary of Defense Caspar W. Weinberger to the Congress on the FY 1987 Budget, FY 1988 Authorization Request and FY 1987-1991 Defense Programs(Washington, D.C.: Government Printing Office, February 5, 1986), p. 229.

[4]John G. Kester, "Slogans vs. Real Issues," Military Logistics Forum. March 1985, p. 10.

[5]Colonel Thomas D. Pilsch. "The Airlift Master Plan: Evolution and Implementation." Defense Management Journal. Fourth Quarter 1984. pp. 25-31.

[6]Defense Report to Congress, p. 230.

[7]Ibid, p. 28.

[8]Caspar W. Weinberger. Report of the Secretary of Defense Caspar W. Weinberger to the Congress on the FY 1987 Budget, FY 1988 Authorization Request and FY 1987-1991 Defense Programs(Washington, D.C.: Government Printing Office, February 5, 1986), p. 5.

[9]Rowland C. Frazee and Thomas P. d'Aquino "Competitiveness and Security: Directions for Canada's International Relations," a response by the Business Council on National Issues to a Paper Tabled by The Right Honourable Joe Clark P.C., M.P., Secretary of State for External Affairs, Ottawa, January, 1986, p. 10. Following the cancellation of the CF-105 Arrow program in 1959, the Canadian Government transferred the large scale Defence R & D from DND to the Department of Industry (now DRIE). For information on the capabilities of the CF-105 Arrow see Jack Woodman, "Flying the AVRO Arrow," Canadian Aeronautics and Space Journal, 25(1) (First Quarter 1979), 1-16.

[10]LtGen K.E. Lewis, CF (Ret'd), testifying before the Senate. Report of the Special Committee of the Senate on National Defence: Military Air Transport,The Honourable Paul C. Lafond, chairman. Issue No. 6. (Ottawa, Ontario, Canada: Queen's Printer

for Canada, June 20, 1985, p. 6:11; and see Canada's Aerospace Industry: A Capability Guide 1985-86, (Toronto, Ontario, Canada: Aerospace Canada International, 1985). While not the subject of this paper, the Canadian aerospace industry very likely has the engineering competence to produce these aircraft as a national aerospace program. Complementing De Havilland's design engineering and STOL expertise would be Canadair with experience in producing large aircraft (of C-130 size), turboprop and jet transports, pilot trainers and supersonic fighters, and a number of component manufacturers who are now supplying U.S. aerospace primes. The capabilities of McDonnell Douglas Canada and the recent purchase of De Havilland by Boeing further extend the capability. The manufacturing capacity is not matched by adequate risk capital, and there is no organizational structure under which the individual companies could group to respond, collectively, to any particular program.

[11]Canada was represented by Mr. T. Chell, Department of External Affairs, Mr. D. Loftus, Department of Regional and Industrial Expansion, and Mr. J. Killick, Department of National Defence.

[12]Dr. Hans Mark, former Secretary of the Air Force and then a Deputy Adminisrtrator of NASA, on 24 November, 1981, suggested that the technology would be appropriate for carrier aircraft. He mentioned, in particular, an AW S-3A, but Lockheed-Burbank did not return the January, 1982 visit by the President and Vice-President Engineering of De Havilland.

[13]The organization and activities of the Air Force Laboratories is explained briefly in, "Air Force Laboratories," Air Force Journal of Logistics, Winter 1986, p. 33.

CHAPTER II

TACTICAL AIRLIFT REQUIREMENTS

Defining the requirement for a new weapons system requires an artful blending of the technologically possible with the operationally necessary and the affordable. The technologically possible, itself, requires risk trade-offs between new technology and incremental advances in proven engineering design. Technology considerations of the Augmentor-Wing (AW) will be left to succeeding chapters. This Chapter will concentrate on the operationally necessary - the requirement for a new tactical airlifter.

TACTICAL AIRLIFT OPERATIONS

Tactical airlifters are rugged aircraft designed for self-sustained in-theater operations. Their loads comprise the vehicles, equipment and troops of the army and, to a lesser extent, the navy and air force. Unlike civilian airliners, rapid on- and off-load of wide-bodied rolling stock, air delivery via air drop or Low Altitude Parachute Extraction (LAPES), in-flight refuelling and a variety of special operations characterize the routine mission mix of tactical airlifters. In western air forces there are a number of tactical airlifters of various capabilities and capacities; however, more C-130 Hercules aircraft have been built and used by air forces than any other modern tactical airlifter. Thus it is the C-130 which has come to symbolize tactical airlift,[1] and which is considered to be the baseline from which to develop a future generation tactical airlifter.

The threat to tactical airlift missions flown in Vietnam[2], the Falklands[3], and Grenada[4] is representative of the future combat environment. Of these the Falklands Campaign affords the unique opportunity to study tactical airlift missions and the combat environment from both sides of the war. The Argentine Air Force (AAF) considered their C-130s "ideal for the mission, but the other aircraft were not, because they were basically airliners."[5] Most flights into Port Stanley's 4,100ft by 75ft strip were at night (a Royal Air Force (RAF) bomb cut the 150' width in half but did not restrict the length), and from about 100 miles out the airlifters would be flown at 50', on the radar altimeter. On reaching the islands, terrain masking was used to avoid being spotted by radar. Night landings were made without approach aids, lights or night vision equipment. Operations persisted under consistently poor conditions, but were cancelled on three days when the crosswinds were 90 degrees to a wet runway. One AAF C-130 was shot down by a combination of AIM-9L and 30mm cannon.[6]

The RAF airlift problem differed from the AAF by adding the complication of great strategic transit distances to the tactical delivery requirement. Ascension Island was the staging base: 3,700nm from England and 3,300nm from the Falklands. The air effort to move personnel, equipment and supplies across these distances highlighted deficiencies in air refuelling (delivering and receiving) and self-contained long-range navigation capability. Quick fixes were improvised. Probes were attached to some C-130s and Victor bombers (too late to be used in the war, other C-130s were fitted with center-line hoses through the cargo door). To overcome the speed differential between the C-130s and the Victor tankers, refuelling was completed while descending at 235 Knots (the Victor overtook the C-130 which plugged in as the Victor came by). RAF C-130s did not land at the Falklands. Supplies were air dropped into the sea, in one-ton waterproof containers, beside a designated ship. This was a time-consuming task as each container had to be recovered before the next one was dropped. The first such C-130 mission took just over 24 hours and covered a distance of 6,300nm.[7]

From these stories of a short, recent war we have seen the C-130 performing the customary tactical airlift missions many of which are, or border on, the domain of special operations: flying in high threat environments, conducting routine and unique air drop and air refuelling procedures over short and excessively long ranges. This inherent flexibility to project intra theater forces over inter theater ranges nets greater mission productivity and must be built into future generation tactical airlifters. The Augmentor-Wing technology could provide the needed capability.

THE UNITED STATES AIR FORCE REQUIREMENT FOR AN ADVANCED TACTICAL TRANSPORT (ATT)

The foregoing wartime account is a vivid aid to understanding that the tactical military airlift mission - to carry the national war fighting capability to and within the combat theater - requires unique capability assets not needed in the civil sector or in a perfectly peaceful world. For the United States, the war fighting capability to be airlifted is predicated on a two-pronged global strategy. In Europe airlift is needed to augment and sustain forward-deployed United States forces. Elsewhere, it is necessary, first of all, to deploy the needed combat capability, and then to augment and sustain it. Secretary Weinberger's succinct analysis of both situations is drawn from his annual report to Congress.

> "Rapid reinforcement is central to a successful defense of NATO. Because the Warsaw Pact maintains a large active military force along its borders with Western Europe, and the road and rail networks would support a rapid enemy buildup, NATO must be prepared to reinforce its in-place forces immediately upon receiving firm indication that a Pact buildup had begun. The timely arrival of reinforcing units from the United States would be key to an effective forward defense during the opening weeks of war, when the risk of a Pact breakthrough would otherwise be high. Our initial reinforcements would include six Army divisions, 60 tactical fighter squadrons, and one Marine Amphibious Brigade -- all of which would have to be delivered to their combat positions, with support detachments, within 10 days of a decision to mobilize. Given the constraints of distance and timing, the forces would have to go by air, and draw on equipment that had been prepositioned for them in Europe in advance."[8]

As the strategic airlift force delivers the estimated 66 million ton miles per day to Europe, it is the tactical airlift task to redistribute the troops, materiel, provisions and repairables to and from the forward areas. Tactical airlift would also move any prepositioned equipment which is at risk of being overrun, or which is needed in another theater at any particular time.

In South West Asia (SWA),

> "The problems we would face in . . . deployment differ from those of a NATO reinforcement in three respects: a Soviet threat to SWA would take longer to materialize because of the limited road and rail systems and the greater distances to be travelled; we have no forward-deployed forces in the region; and we, too, would have to contend with limited road and rail systems, as well as limited port facilities. A deployment to SWA would require moving our forces some 8,000 nautical miles by air (nearly double the distance to Europe) and more than 12,000 nautical miles by sea (more than three times as far as to Europe). At their desti-

> nation, our troops would be operating from ports and airfields that lack the modern cargo-handling equipment found at European facilities. Moreover, since no US combat units are based in SWA in peacetime, we would have to deploy an entire fighting force, with all of its support elements -- and do so very quickly."[9]

The military airlifter with its roll-on, roll-off capability is inherently designed for these combat areas which lack, or have poor quality, airfields, personnel and cargo-handling facilities where the redistribution task of the tactical airlift fleet is compounded.

The USAF has 518 tactical airlift C-130s. The Secretary does not envisage any growth in fleet size, but the next tactical airlifter will require greater capacity or productivity, or both. The speed and payload/range capabilities of an enhanced STOL Augmentor-Wing tactical airlifter provide the spectrum of capabilities needed by the United States.

THE CANADIAN REQUIREMENT

The Canadian requirement for tactical airlift differs from the United States in two distinct ways. First, Canadian defence policy is predicated on national, not global, policy objectives except for two key alliances: NATO and NORAD. Second, since Canada does not have a strategic airlift fleet for reinforcement and resupply of European NATO, her tactical airlifters fall heir to that task. The deployment and sustainment of NATO-committed Canadian Forces require the entire airlift fleet: leaving no aircraft for other priority national defence tasks. Even then the fleet size is inadequate, as reported in two recent studies concerned with Canadian defence capabilities by the Senate of Canada,[10] and the Canadian Business Council on National Issues.[11] The Senate Committee confirmed " . . . what it had expected to find:

> Air Transport Group's fleet lacks numbers, is over utilized and suffers from increasing obsolescence." . . . "Our present Hercules fleet is inadequate and aging. It needs to be almost doubled in size. Present holdings should be updated and life-extended to meet the various requirements they are likely to face in the next decade."[12]

The basis for the Senate Committee conclusion that the airlift fleet needs to be almost doubled in size is the NATO commitment requiring "extensive" in-theater operations as well as heavy strategic airlift. This leaves no tactical airlifters to support Defence of Canada or Defence of North America war tasks, or the continuing support tasks for which only tactical airlifters are suited. Moreover, "NATO strategists now believe that a land war in Europe could conceivably last several months."[13] The longer the war, the greater the attrition and the larger the requirement.

The limited size of the Canadian Forces authorized tactical airlift fleet (28 C-130s) compared with defence commitments has resulted in utilization rates at, virtually, wartime levels. CF C-130s are flown in excess of twice the rate of USAF, or most other air force, C-130s resulting in faster aircraft aging, and the erosion of the reserve capacity of a "younger" fleet at the outbreak of war. Thus, the peacetime C-130 fleet could be doubled in size from 28 to 56 C-130s[14] just to correct the uniquely high utilization rate by halving it. In wartime this "doubled" fleet could be flown at twice the normal peacetime flying, or utilization, rate and fulfill the current NATO commitments.

For years Canadian governments have expressed an interest in stronger Northern and Arctic defences. The CF-18 is tasked to operate from Forward Operating Locations (FOLs)in the North, but will require tactical airlift support. As well, all CF-18s can be air-refuelled. The force multiplier effect of in-flight refuelling prompted the Senate Committee to recommend the acquisition of six tactical airlift tankers.[15]

For the Defence of Canada, the Senate acknowledged that the, "Canadian Forces must have the air transport capability needed to airlift a brigade of troops to any Northern or coastal points which may be threatened by disorders or outside interference or incursion."[16] Fleet size would depend upon the time within which the force was to be assembled and deployed and whether this task is to be double-hatted with the NATO commitment, or a stand-alone commitment.

The Senate Committee looked across the Air Transport Group (ATG) inventory and commented on the variety of dissimilar aircraft performing airlift tasks. Citing the logistics, training and operational benefits of commonality in aircraft types, to the extent possible, recommendations were made on replacing most of the old CF aircraft with larger fleets of fewer types of modern aircraft. Except for the call for more C-130s, the recommendations focussed on utilizing aircraft currently produced in Canada. An alternative plan is worth considering.

The aircraft to be replaced include the nine venerable Dakotas (C-47s), fourteen Buffalos (C-8Bs) and eight Twin-Otters. The Dakotas are Air Reserve aircraft which have an airlift role but limited capability. The Buffalos and Twin-Otters have two roles: Search and Rescue (SAR) and tactical airlift. These 31 aircraft perform two tasks which the C-130 is designed for and does in air forces around the world: tactical airlift and SAR. A common C-130-type airframe to replace these 31 aircraft added to the six tankers and the 56 required for the tactical airlift mission would realize the economies of scale the Senators were seeking and enhance operational effectiveness. Buying U.S.-made C-130s off-the-shelf would not address the need to stimulate the Canadian aerospace industry, which was the thrust of Committee recommendations for acquiring more of the types of aircraft currently made in Canada. An augmentor wing version of the C-130 or new tactical airlifter would satisfy both requirements. The ninety-three aircraft needed to meet the tasks identified by the Senate Committee would go a long way towards the break-even point of an an augmentor wing tactical airlifter project, making it a viable and affordable proposition. Acquisition of a fleet of this size using Canadian technology makes good political sense, even for a domestic stand-alone project, although the production run might not be quite enough to reach the break-even point. A few small customers added to the CF requirement could make the project not only affordable, but profitable. Clearly a requirement of this magnitude is an attractive nucleus for a joint project with a major partner who would share the risk and up-front investment while cooperatively developing and phasing in the new aircraft.

OTHER NATION REQUIREMENTS

Approximately three years ago, aerospace industry representatives of four countries initiated discussion on a collaborative project to develop a C-130 replacement labelled the Future International Military Airlifter (FIMA). The consortium comprised Lockheed (USA), MBB (Germany), Aerospatiale (France) and British Aerospace (UK). The objective of FIMA is for those companies to produce a single set of specifications that would meet the needs of their national air forces. Broad agreement has been reached on a single design; however, details have been witheld from non-participants.

What seems to be emerging from FIMA is an aircraft not too dissimilar from the C-130 or the Transall which would enter service near the end of this century. The aircraft must be developed from the outset as a rugged military aircraft optimised for intra-theater operations and built to low-unit cost. Take-off and landing performance must be better than the current C-130. Improved speed/payload/range is required to be capable of long, unrefuelled flights with a useful payload at .7 or .8M cruise. The RAF requires a larger cargo capacity than the current C-130 (De Havilland has done parametric studies of a wide-bodied C-130 which would likely satisfy this need. As well, the augmentor wing with its lighter structural weight would make the stretched C-130 more productive). These requirements almost certainly result from an analysis of the Falklands Conflict as discussed above.

The early meetings of FIMA also included planning for strategic airlifters. In November, 1984, European Defence

Ministers agreed to collaborate on a Future Transport Aircraft (FTA) in a purely European context. In June, 1985 Ministers urged that the work under the Independent European Programme Group (IEPG) should be extended to include future requirements for Airborne Early Warning (AEW), Maritime and Tanker aircraft under the catch-all title Future Large Aircraft (FLA). There does seem to be support for rationalising the military fleets of large aircraft around a single design, essentially derivatives of a basic military airlifter. Initial Operational Capability (IOC) dates are expected to be between 2000-2010. The staffing of mission needs documents and staff targets is currently in progress.

These two initiatives were planned by the Europeans as means of speaking with a single voice on their future airlift requirements - aircraft which could also be common NATO military airlifters,and perhaps tanker, ASW and AEW aircraft. If NATO is to develop aircraft common to the entire alliance, discussions need to be opened with the United States and Canada. Certainly, the Canadian Senators have called for this in their report on military air transport discussed above. More importantly, the baseline requirements compare very favorably with the Canadian and United States needs and the augmentor-wing technology is very likely the best way to achieve the low-cost, low-risk performance benefits the Europeans seek.

Recent discussions between officials of the Canadian Department of External Affairs (DEA) and the Australian Government indicate RAAF interest in exploring the possibility of converting their C-130s with the augmentor wing. The RAAF and CF fleets are about the same size. No other details of the RAAF requirements are known at this time.

For all of the differences in the descriptions, or definitions of individual requirements, there are great similarities amongst the tactical airlift needs of air forces. These similarities could be the foundation of a cooperative development project. The scope of such a project could vary from a technology demonstration of specially modified Augmentor-Wing versions of the C-130 to development and production of a new generation tactical airlifter incorporating the Augmentor-Wing. Current USAF and European planning centers on an all-new aircraft. This may, in the end, be the most practicable solution, but alternatives will be examined in succeeding chapters.

Notwithstanding Canada's technology lead, the initiative and choice for tactical airlift enhancement through a major aircraft modification or new production aircraft rests with the governments of those air forces which require sufficient numbers to be able to amortize reasonably the development costs. The European cooperative approach commends itself to a broader group of allies. The joint production process is still foreign to North Americans, although the realities of Gramm-Rudman-Hollings may eventually impose such solutions.

Currently, USAF planners are examining their own requirement for a tactical airlifter at the turn of the century. The first step in the process is the preparation of a Statement of Need (SON) by the operational command, Military Airlift Command (MAC) Headquarters staff. Supporting studies are being coordinated through the Requirements Planning Department of Aerospace Systems Division (ASD/XRM), at Wright Patterson Air Force Base.

TACTICAL MOBILITY MISSION ANALYSIS (TMMA).

The first of these supporting studies is a Tactical Mobility Mission Analysis (TMMA) of the requirement for an Advanced Tactical Transport (ATT) when the USAF C-130 aircraft reach the end of their economic lives in the first decade of the 21st century. The study is oriented towards the user's needs in the operational combat environment envisaged during the life of the aircraft in the next century. Inputs have been sought from key Army and Air Force staffs [Figure 2] (particularly the Combined Arms Center, Fort Leavenworth, Kansas and the Airlift Concepts Requirements Agency at MAC HQ), responsible for doctrine or operational planning. Considerable attention has been given to the lessons of history, as applied to tactical airlift, as well as the thinking contained in the latest draft of the Airland Battle 2000,[17] for example, in order to gain greater insight into the intratheater tasks of the next century.

Reflecting the times and the electronic battlefield, much of the analysis is devoted to threat, to include the need for greater survivability through EW protection, active self-defense and the use of maneuver and speed at low altitude. Army and Air Force planners share concerns over the need to minimize the time aircraft and paratroops are exposed over drop zones. Possible solutions being discussed include paratroop drops at 250 Kts from 300 feet, squad or platoon sized airdrops on pallets and airdropping on coordinates without slowing down. An AW aircraft capable of rapid deceleration and acceleration, and safe and comfortable low flight at slow speeds (e.g., 65 to 80 kts LAPES) would provide an attractive capability.

The maximum numbers of airlifters on the ground (MOG) is seen as the critical factor in delivering airlift loads to airheads. A sortie effectiveness model is being developed to determine the optimum means of sortie generation.[18] This will include maintenance factors, MOG, and the use of intermediate airheads. In certain scenarios, a steady and sustained flow of aircraft, as currently planned, could choke the facilities and capacity of the destination airfield. In such cases aircraft would be held on the ground at an intermediate departure point awaiting an offloading slot at destination before being authorized for take-off. A high dash speed capability, such as offered by an Augmentor-Wing aircraft, would facilitate a future airlifter's capability to respond.

Not surprisingly, the TMMA study uses the C-130 (updated to the year 2010), its strengths and deficiencies, as a comparative baseline. Industry respondents are co-participants in the study which was initiated in July, 1985. Industrial participants will consider and propose design criteria, technology opportunities and systems concepts for the new tactical airlifter, then join ASD in the conduct of an internal evaluation, or validation, of their analyses. Study completion is scheduled for July, 1987.

SUMMARY

The USAF and her allies all appear to have quite different specific requirements for a new tactical airlifter. Yet, their proposed solutions are strikingly similar. The baseline aircraft is a C-130, or somewhat larger version of one, with

much improved STOL performance, longer range, better payload/range, higher speed (M.3), and overall better productivity and efficiency. Some air forces need a tactical airlifter which can also operate over strategic ranges. Any air force would benefit from this capability. The Augmentor-Wing technology seems tailor-made for all of these requirements. Subsequent chapters will discuss how.

NOTES

CHAPTER II

[1]Joseph Earl Dabney. Herk: Hero of the Skies. (Lakemont, GA: Copple House Books, 1979).

[2]Ray L. Bowers. Tactical Airlift: The United States Air Force in Southeast Asia, (Washington, D.C.: Office of Air Force History, 1983).

[3]Jeff Ethell, "The Makeshift War," Military Logistics Forum, March 1985, pp. 45-52.

[4]cf.LtCol Michael J. Byron, USMC. "Fury from the Sea: Marines in Grenada," U.S. Naval Institute Proceedings, May 1984, 119-131; and Stephen Harding. Air War Grenada, (Missoula, Montana: Pictorial Histories Publishing Company, 1984).

[5]Ethell, p. 46.

[6]In Vietnam a USAF C-130 refuelling helos was much luckier when it was jumped by a MIG-21. While one helo was destroyed the other aircraft awaiting refuelling and the tanker escaped. The C-130 evaded by rolling and diving maneuvers down to tree-top level and then sustained violent yawing and rolling maneuvers. The MIG, having missed on its initial passes slowed down for a more acurate shot. The MIG-21 got so slow the nose "tucked". Without sufficient altitude to recover from the stall, the MIG crashed. In spite of the harrowing experience, the crew were not credited with the kill, decorated or otherwise honored.

[7]De Seversky envisaged a need for 6,000nm ranges in his 1942 book Victory Through Air Power, as quoted in Air Force 2000 and cited by Dr. Leonard C. Gaston, "Planning for Force Projection," in Air University Review, XXXVI(2), (January-February 1985), 91.

[8]FY 1987 Report of Secretary of Defense Caspar W. Weinberger, 235.

[9]Ibid.

[10]Report of the Special Committee of the Senate on National Defence: Military Air Transport The Honourable Paul C. Lafond, chairman.(Ottawa, Ontario, Canada: Queen's Printer for Canada, February 1986)

[11]"Canada's Defence Policy: Capabilities versus Commitments," A Position Paper of the Business Council on National Issues Task Force on Foreign Policy and Defence, Peter A.G. Cameron, chairman. Ottawa, September, 1984.

[12] Senator Paul C. Lafond. Report of the Special Committee of the Senate on National Defence: Military Air Transport The Honourable Paul C. Lafond, chairman. (Ottawa, Ontario, Canada: Queen's Printer for Canada, February 1986), pp. xiii-xv.

[13] Ibid, p.2.

[14] The Senators settled on 47 aircraft based on the task, but without considering attrition or utilization rate. Fifty-six tactical airlifters would be required to cut the peacetime flying rate in half and it is the number required to complete the mission within the time constraints and allow for 20 percent attrition. This assumes that the C-130s are fully dedicated to the deployment as no C-130s would be available for concurrent tasking.

[15] Ibid, p.21

[16] Ibid, pp.20-1

[17] "The Fundamentals of Airland Battle Doctrine," Draft Chapter 2 of U.S. Army Doctrine Manual FM 100-5 dated 18 October, 1985; John L. Romjue. From Active Defense to Airland Battle: The Development of Army Doctrine 1973-1982. (Fort Monroe, VA: United States Army Training and Doctrine Command, 1984). An interesting series of articles on the AirLand Battle are contained in Combat Weapons. Summer 85, pp. 15-55.

[18] Based on a program contained in a thesis written at AFIT by Capt. Tom Manacapilli, USAF, "A Methodology for Identifying Cost Effective Strategic Force Mixes."

AIRLIFT INFORMATION SOURCES

UNIFIED COMMAND	U.S. EUROPEAN COMMAND (STUTTGART, GE)
U.S. AIR FORCE	
TAC (LANGLEY)	AIRLIFT CENTER (POPE)
MAC (SCOTT)	RED FLAG (NELLIS)
AFLC (W.P.)	USAFE (RAMSTEIN, GE)
AFSC (ANDREWS)	322ND AIRLIFT DIV (RAMSTEIN, GE)
USAF (PENTAGON)	435TH TACTICAL AIRLIFT WING (RHEIN-MAIN, GE)
FTD (W.P.)	
U.S. ARMY	
TRADOC (FT MONROE)	82ND AIRBORNE DIV (FT BRAGG)
COMBINED ARMS CENTER (FT LEAVENWORTH)	LOGISTICS CENTER (FT LEE)
	VII CORPS (STUTTGART, GE)
COMMAND & GEN STAFF COLLEGE (FT LEAVENWORTH)	V CORPS (FRANKFORT, GE)
	U.S. ARMY, EUROPE (HEIDELBERG, GE)
U.S. MARINE CORPS	
DEVELOPMENT & EDUCATION COMMAND (QUANTICO)	

Figure 2

CHAPTER III

SPECIAL OPERATIONS REQUIREMENTS

The Special Operations Force (SOF) evolved from the USAF Special Air Warfare Center (SAWC). SAWC was originally established to train friendly foreign forces in the employment of counterinsurgency (COIN) techniques in their homeland, and not to create a new combat capability within the USAF. Eventually, the capability in "low-level parachute resupply, close air support, use of flares for night operations, assault takeoffs and landings, psychological missions with leaflets and loudspeakers, and other counterguerilla techniques."[1] was needed by the USAF, itself, in Vietnam. Now, under the general heading of special operations are several specific tasks currently being performed by C-130-derivative aircraft which outline the capability being sought in a new tactical airlifter.

EC-130H COMPASS CALL

The Compass Call is a specially configured C-130 aircraft designed to disrupt enemy communications systems from standoff ranges. There are currently nine in service and DOD is seeking six more conversions.[2]

MC-130H COMBAT TALON

The Combat Talon is a tactical support aircraft flown by the Special Operations Forces. Its primary mission is to drop combat personnel and equipment behind enemy lines. An array of special navigating and self-protection devices help the aircraft fly through enemy airspace at night and at a low enough altitude to avoid radar detection. The air force plans to acquire a total of 35 Combat Talons, of which 14 will be modified C-130s and the remainder new-production models (MC-130Hs). All of the modified aircraft are already in service. Five of the new aircraft are on order, with deliveries scheduled to begin in 1988. Together with the FY 1986 authorization, the FY 1987-91 program provides funds for the remaining 16 aircraft, all of which are scheduled to enter service by FY 1993.[3]

AC-130 GUNSHIP

The AC-130 is a modified C-130 aircraft whose primary mission is to provide support for special operations and for conventional targets by employing its highly accurate guns[4] against enemy targets. The aircraft is configured with a precision-navigation system, terrain-following radar, and electronically aimed weapons. Deliveries of the 12 new-production aircraft will begin in FY 1990 and continue through FY 1992, offsetting the retirement of older-model aircraft. The new gunships will help revitalize "our" special operations forces.[5] A taste for the utility of the AC-130 is expressed by General Momyer:

> The "...AC-130 and its sophisticated sensor system . . . proved the best weapon system . . . for [nighttime] target acquisition. With its low light TV or infrared sensor, the AC-130 was able to mark targets . . . accurately . . . for follow-on attacks by fighters . . . deliver direct fire against tanks and . . . use laser designators [to] . . . illuminate targets for fighters to attack with laser bombs.[6]

There are similar stories throughout the Vietnam War, but few capture the hostile environment or the variety of tactical airlift tasks better than the ill-timed, but otherwise imaginative raid to release prisoners of war from Son Tay.[7]

High altitude "strafing" by gunships was not the only offensive task of C-130s. In a discussion of the use of Soviet airlifters in Afghanistan, it has been said,

> " . . . the Soviets may be copying U.S. transport tactics used in Vietnam. Some sources have suggested that AN-12 Cub transports have been used as bombers by rolling bombs down and off the tail ramp while in flight. In Vietnam, the United States used 15,000-pound bombs dropped from C-130 transports to clear helicopter assault zones in the jungle."[8]

SEARCH AND RESCUE (SAR)

When one thinks of C-130s in the SAR role, the United States Coast Guard (USCG) comes readily to mind. Their long ranging patrols searching for and providing assistance to vessels at sea requires the capability for sustained operations, high reaction speed, and low, slow flight in abysmal weather conditions. The Coast Guard SAR task is representative of the peacetime SAR mission in most countries. In wartime, Combat SAR introduces new threats to the rescue forces. In Vietnam the USAF SAR forces enhanced their SAR effectiveness through the novel use of the inherent flexibility of design and function of the C-130. The USAF found rescue was facilitated by exploiting the airlift (C-130s), gunship (AC-130s), rescue communications and control (HC-130Hs),[9] and even in-flight refuelling capability (USAF HC-130Ps[10] and USMC KC-130s) of the respective versions of the C-130. Time and circumstances were right for the "Herc," which played a key role in the rescue of 3,883 souls.

Now, the electronic battlefield and the even more sophisticated air-to-air and surface-to-air threat[11] suggests the next generation rescue aircraft will require greater inherent capability for manoeuvre. Ideally, a SAR aircraft would have a speed range from zero (VSTOL) to high subsonic forward speed.

IN-FLIGHT REFUELLING

In-flight refuelling permits aircraft to remain on station longer, to achieve mission lengths over longer ranges, and even to avoid the loss of combat crews and aircraft which would otherwise have been lost due to a shortage of fuel, as happened so often in Vietnam.

> ". . . all missions going into Route Package VI were air refuelled. . .Four fighters refuelled by a single tanker, took on 10,000 to 12,000 pounds of fuel each. . .more than 60 aircraft would take on fuel within a few minutes of each other. . . sufficient fuel for . . . 15 to 20 minutes without afterburner in the target area before turning home. . .coming back. . .most...required another air refuelling."[12]

The USAF had before Vietnam primarily concentrated on the use of in-flight refuelling as a means of extending the reach of the nuclear strike force. The USMC and USN, on the other hand, had exploited KC-130s to refuel tactical fighters and the USMC pioneered the in-flight refuelling of helicopters in 1965. As it was so well proven in Israeli attacks on Egypt in the 1960s, in Vietnam and in the Falklands, the in-flight refuelling of tactical aircraft:

> " . . . provided a totally new dimension to air defence and attack operations by permitting greatly increased ranges to be achieved by inherently short-range tactical aircraft . . . expanded the tactical options open to a commander in the employment of air power by allowing him to switch aircraft between tasks and geographic areas swiftly and decisively. Time, so often at a premium in operational situations, can now be utilised to much greater advantage. This leads to flexibility of options, concentration of force at the critical time and place, and surprise. These factors, and the improved cost-effectiveness in the employment of resources which they offer, have been fully accepted by US and British forces.[13]

The cost-effective force multiplier effect to be realized from an inherent in-flight refuelling capability suggest all tactical aircraft, including tactical airlifters, should be capable of taking fuel in flight, and all tactical (and strategic) airlifters should be inherently capable of giving fuel in flight. It would not be practical for airlifters to continually carry the drogues or internal tank (however, a probe or an external fitting for a probe could be flush-mounted), but their basic design configuration should include the plumbing and systems necessary to convert them quickly to tankers as and when necessary.[14]

The broad speed envelope of the Augmentor Wing aircraft is well suited to air refuelling. Its M .8 cruise would permit fighters to refuel efficiently at altitude [Figure 3], and the inherent slow flight capabilities would permit equally efficient air refuelling of slower aircraft and helicopters at lower altitudes.

In Vietnam the C-130 earned a well deserved reputation for its flexibility in a variety of roles. That it did so is attributable to the persistence of individuals who prevailed against the predominantly "party-line," or institutional thinking.[15] Following Vietnam the SOF forces which used a variety of tactical airlifters so imaginatively and effectively in combat and combat support roles were permitted to decline. Unique skills were lost and doctrine and tactics were not recorded. In spite of stated intent to beef up the SOF, little tangible evidence exists of a top-down policy to solidify and expand SOF capabilities in spite of the known need. The planned aircraft procurement programs cited above are badly needed. The conviction with which DOD and USAF support SOF today will be evidenced by the rate of implementation of these programs.

SUMMARY

From special operations entailing unique surveillance capabilities, or the tactical support of low intensity conflict there has emerged a requirement for a tactical airlifter with high dash and low loiter speeds, which can operate independently at extreme ranges, and from very short austere airfields with payloads up to 27,000lbs. An Augmentor Wing tactical airlifter with its broad operational performance spectrum would be a vast improvement over the C-130 in all Special Operations areas: Compass Call, Combat Talon, Gunship, Tanker, SAR etc. Its safe, slow approach and landing speed and enhanced field performance would open numerous shorter and narrower airfields[16] while enhancing the likelihood of continued operations from bombed runways and in poor weather.

NOTES

CHAPTER III

[1]Lieutenant Colonel David J. Dean. "The USAF in Low-intensity Conflict: The Special Air Warfare Center," Air University Review, XXXVI(2), (January-February 1985), 50.

[2]FY 1987 Annual Report of Secretary of Defense Caspar W. Weinberger to the Congress, 208.

[3]Ibid, 201

[4]Jack S. Ballard. Development and Employment of Fixed-Wing Gunships, 1962-1972. The United States Air Force in Southeast Asia Series, (Washington, D.C.: Office of Air Force History, 1982), p. 126; and Major A.J.C. Lavalle, ed. Last Flight From Saigon, Vol. IV of the USAF Southeast Asia Monograph Series. (6th Monograph; Washington, D.C.: Office of Air Force History, 1985), p. 102.

[5]FY 1987 Annual Report of Secretary of Defense Caspar W. Weinberger to the Congress, 202.

[6]General William W. Momyer, USAF (Retired). Air Power in Three Wars: WWII, Korea, Vietnam. (Washington, D.C.: Office of Air Force History, 1985). P. 282.

[7]Earl H. Tilford, Jr. The United States Air Force Search and Rescue in Southeast Asia, 1961-1975. (Washington, D.C.: Office of Air Force History, 1980), pp. 103-112; or see Benjamin F. Schemmer. The Raid, (New York: Harper and Row, 1976).

[8]Lieutenant Colonel Denny R. Nelson. "Soviet Air Power: Tactics and Weapons used in Afghanistan," Air University Review, XXXVI(2), (January-February 1985), 32.

[9]Tilford, pp. 152-4.

[10]Eleven HC-130P airborne mission control/tanker aircraft had seen prior service as HC-130Hs airborne mission control aircraft before being converted to tankers by Lockheed in their plant at Marietta, Georgia. (Tilford:112) Interestingly, fifteen years later Lockheed sales reps advised Canadian Forces air staf.s that this modification had not been done and was not possible because working in the wing area would cause permanent fuel leaks.

[11]Tilford, p. 156.

[12]Momyer, p. 228.

[13]John Turner. "Air-to-air refuelling: its contribution to cost-effective air operations," Jane's Defence Weekly, 3(4) (26 January 1985), 148.

[14]A KC-130 which has its internal tank and wing drogue pods removed suffers a minor payload penalty, unlike the comment which appeared in "Air-to-Air Refuelling in the RAF," Air Clues, (July 1984), 244 which erroneously concluded the tanker configuration precluded its use as an airlifter or dual roled as a tanker/airlifter.

[15]Donald J. Mrozek. "The Limits of Innovation: Aspects of Air Power in Vietnam," Air University Review, XXXVI(2), (January-February 1985), 60.

[16]Lieutenant Colonel Price T. Bingham. "Improving Force Flexibility through V/STOL," Air University Review, XXXVI(2) (January-February 1985), 76.

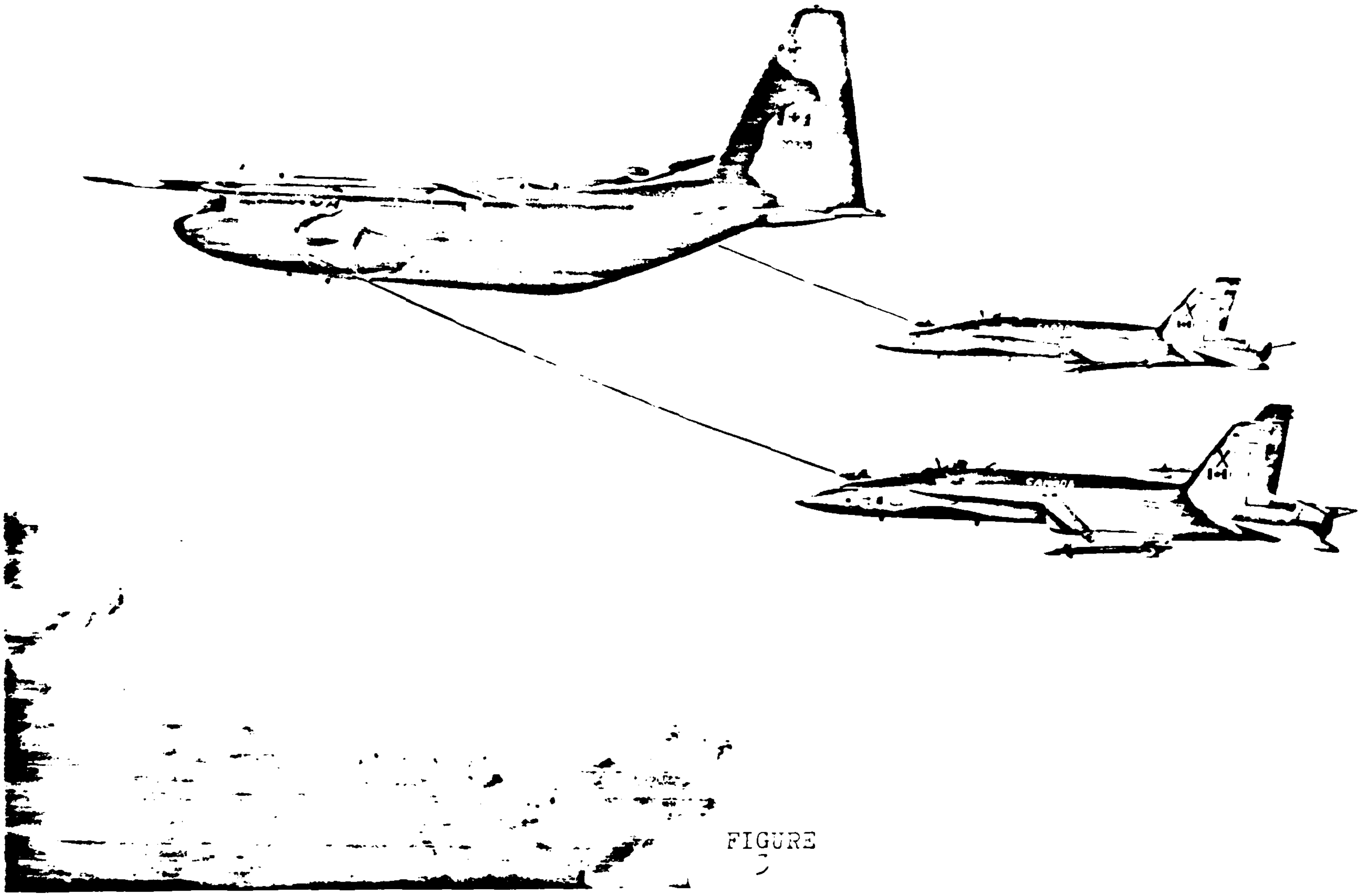


FIGURE 7

reasonable number of C-130s would be candidates for augmentor wing conversion.

C-130 PL PERFORMANCE

The C-130PL performance predictions are juxtaposed with the USAF Request for Proposal (RFP) performance criteria below:

SPECIFICATIONS	RFP	C-130 PL
SIZE	C-130	C-130
WING AREA	1,700-3,135 sq ft.	1,745 sq ft.
ASPECT RATIO	6.34-8	12
THICKNESS/CHORD RATIO	12-14	24
PAYLOAD	44,000LBS	44,000LBS
Note: the C-130 PL carries an integral		6,200LBS ECM fit.
Thus, C-130 PL effective payload is:		50,200LBS.
COMBAT LOAD	27,000LBS	44,000LBS
DASH SPEED	M 0.7-M 0.85	M 0.8
RANGE WITH 36,000LBS	1600nm	4,000nm
STOL WITH 36,000LBS	1500 feet	<1000 ft grnd roll
STOL <36,000LBS		500ft grnd roll
VTOL	0-300 feet	0 achievable with tilt wing.[3].
ENGINE OUT	10% Reduction OK	Capable of SE T/O.*

*Single Engine take off at mid mission wt.(36,000lbs. payload).

The RFP specifications listed above combine the features of the two "test" aircraft designs of the Advanced Tactical Transport Technologies (ATTT) study. The Augmentor Wing C-130 PL compares extremely well; particularly in payload/range, STOL and speed.

weight.

The C-130 PL retains the wing area of the original C-130H. Design Gross Weight is increased to 180,000 lbs. with an overload weight of 205,000 lbs.

Performance.

The thick wing provides the design advantage of low structural weight, and ample space for the cross ducting behind the rear spar. Operational benefits accrue from the high lift without leading edge devices, and the greater flexibility in payload/range (trade-off) combinations due to the large internal fuel capacity.

> "The aircraft is well suited to either a tactical assault radius mission or to a tactical support range mission. STOL capability of the aircraft is defined in terms of field performance at the mid-point of a radius mission in which payload carried out of the field is equal to payload delivered. Also, it is assumed that the aircraft does not take on fuel at the mid-point."[4]

Range.

A comparison of payload/range capabilities between the C-130 PL and the C-130 is made at Figure 6-1. The chart has two deficiencies. First, it plots performance against the C-130 PL Overload weight of 205,000 lbs, but not the C-130H overload weight of 175,000 lbs. Second, it compares performance against the same payload of 44,000 lbs., when the C-130 PL is carrying an extra 6,200 lbs. of electronic equipment for an effective payload of 50,200 lbs, or 18 percent more than the C-130.

Low Level Radius Mission.

The tactical radius at 50 feet above ground level, with full payload, is in excess of 500nm. The radius can be extended even further with smaller payloads and more fuel: to the point where additional fuel could be carried internally in tanker configured variants.

Takeoff Performance.

Takeoff distance with all engines operative is shown at Figure 6-2, and corresponding lift-off speeds are at Figure 6-3. "It is the cross-ducting which renders the aircraft controllable . . . at low speed and which permits payload and/or fuel to be off-loaded in order to achieve a shorter field capability for special missions. In particular, note that takeoff distance out of the mid-point with one engine disabled and zero payload is approximately equal to the "all-engines" case with payload."[5]

Landing Performance.

The landing distance versus weight is shown at Figure 6-4, with the corresponding approach speeds at Figure 6-5. Full braking is effective two seconds after touchdown, but ground roll has been calculated without reverse thrust.

AUGMENTOR WING TANKER

The C-130 PL has many advantages in the tanker role. Its high altitude and high speed facilitate in-flight refuelling of fighters, and its exceptional low altitude, slow speed performance facilitate helicopter refuelling. Its payload/range flexibility make the "KC-130 PL" [Figure 6-6] tanker suitable for refuelling a broader variety of aircraft over wider-ranging geographic rendezvous areas. "The thick supercritical wing provides for substantial fuel capacity in the wing box which then avoids the need to carry fuel externally. In the tanker role, fuselage tanks are fitted holding about 23,000lb of fuel."[6] Figure 6-7 shows transfer fuel versus radius of action for the augmentor wing version of the C-130 versus the tanker version of the C-130H.

ADVANCED TACTICAL TRANSPORT

The USAF search for an Advanced Tactical Transport (ATT) under the Tactical Mobility Mission Analysis (TMMA) studies is matched by the Future International Military Airlifter (FIMA) in UK, France, and W.Germany, and the Canadian augmentor wing development known as the Advanced STOL Transport (AST). These have much in common. They all are essentially growth versions of the C-130 (in the 200,000lb plus category), have two or three turboprop or turbofan engines, and have improved STOL, payload/range and speed performance: the ingredients for a joint or collaborative, or "coalition," development program.

> "The historic intent of the Congress remains as clear today as it was in its early charge to the [Secretary of Defense] --to assume responsibility for enhancing effectiveness, economy, and efficiency in management activities common to more than one military department."
> "What is different is that vastly greater threats now demand cooperation and efforts to achieve combined effectiveness in ways which could not have been foreseen when Congress enacted the DOD charter into law."[7]

When writing those words, Dr. DeLauer did not anticipate the extraordinary "threat" to DOD posed by the Gramm-Rudman-Hollings amendment, or the congressional and public pressures for DOD to tighten its belt. Dr. DeLauer was a strong advocate of working more closely with the allies in joint R & D. Was his interest based on the knowledge that the ally is more likely to participate in the deployment of a system it can point proudly to and say "it was made here?" European consortia have been very successful in implementing shared weapons system programs. Some of those programs may not appear to have made sound short term "business" sense because the per unit cost is relatively high. The long term benefits from a stronger European industrial base, higher levels of employment and the international political and trade benefits of cooperative enterprise and defense systems development will pay handsome future dividends compared with the initial investment and higher per unit cost in the early years. Those same pressures which caused our European allies to jointly produce the Jaguar, Tornado, Transall and Airbus, for example, are mounting in North

America. It is time to join in a cooperative military aerospace program, and the augmentor wing technology provides a timely and effective vehicle. Secretary Weinberger's report suggests that Congress may be leading the way with its support to certain other coalition programs.

> "The Congress provided strong support for U.S.--allied arms cooperation in FY 1986 by earmarking $200 million for NATO cooperative research and development programs, appropriating $100 million in new funding for these efforts, establishing a program for side-by-side comparative testing, and passing enabling legislation for flexibility in contracting."[8]

It may be argued that $200 M is not much. That depends on whether you are looking down from 35 billion or up from zero. It is an important opener - particularly when multiplied by the number of contributing participants.

Dr. DeLauer's article went on to pose four questions to test the validity and worth of joint programs.

The first criterion: "Where will investment in these tools make a real difference?" "Economy and efficiency are still cornerstones of any cooperative effort. But the bottom line must remain combat effectiveness. "Achieving that goal at the lowest possible cost is our common purpose."

"The second criterion is: "Will the joint effort support our military doctrine?"

The third criterion is: "Is there joint agreement on the mission needs?"

The fourth and last criterion is: "Does it make sense?"[9]

In answer to the first question, a program is most likely to be implemented at the lowest possible cost when there are large numbers of the same item produced, and when the development and production risk is low. As may be seen from the requirements chapter, with any combination of allied partners in a cooperative augmentor wing program it is likely to quickly achieve the numbers of aircraft needed for a "lowest cost" production. Indeed, it might be argued that the partners (Canada for example) would be more likely to reequip more of their force with augmentor wing derivative tactical airlifters than off-the-shelf aircraft of foreign manufacture. With respect to risk, the augmentor wing technology has a substantial technical data base from the joint Canada/U.S. technology research programs. The research aircraft and wind tunnel projects have reduced technical risk to a minimum; thus, the program may be seen to be well down, in the crossover area of, the risk/cost profile chart used by the Executive Office of the President in systems development decision making [Figure 6-8]. In fact, the technology for engine and augmentor wing both is sufficiently advanced that an all new tactical airlifter could be built without a demonstrator phase, and by using the first production aircraft as the prototype.

In answer to the second criterion, augmentor wing development supports military airlift, combat search and rescue, and special operations doctrine.

The third criterion is equally easily answered. Each nation cited in the requirements chapter has agreed on mission needs which are comparable to the other nations. Moreover, the augmentor wing technology meets or exceeds those needs.

To answer the fourth criterion, yes, it makes sense. It makes economic and political sense, but more importantly, it makes operational military sense. This is a rare combination which should be savored.

The augmentor wing tactical airlifter meets Dr. DeLauer's criteria for a joint program.

FUTURE LARGE AIRCRAFT (FLA)

The European FLA envisages strategic airlift, Airborne Early Warning (AEW), Maritime Patrol (MP or VP), and strategic tanker requirements being satisfied by respective variants of a common airframe. Requirement details are not yet known, but the aircraft is likely to be between C-141 and C-17 size, with the smaller C-141 size being more appropriate to the maritime role. The Boeing 707 may be considered an early U.S. version of the FLA - although it does not have the wide-bodied oversize cargo capacity, it has performed all of the other roles except maritime patrol (a 707-320 was a serious contender for the Canadian Long Range Patrol Aircraft competition in the mid 1970s). The European aerospace industry is undoubtedly trying to emulate Boeing's success in building multiple mission military derivatives of a common airframe.

De Havilland has conducted parametric studies of three and four engined airlifters up to 500,000 lbs. Payloads equalled 25 percent of design gross weight. Wing areas were predicated on fuel capacity for the stated mission stage length and then increased incrementally to 130 per cent of requirement. Using an 8,000 foot strip for the original mission takeoff, 900 to 1100 foot takeoffs are practical at the mid-point. (whereas a STOL takeoff at design gross weight incurs a moderate penalty in fuel efficiency, thus a conventional takeoff roll is deemed more appropriate). The De Havilland research could be applied to the FLA series aircraft. While beyond the purview of this paper, North American and European NATO requirements for modern maritime patrol, and airborne early warning aircraft, and strategic ranged airlifters and tankers merging early in the next century should be compelling motivation to develop a single baseline aircraft for each role, and then to share in their systems integration.

SUMMARY

In this chapter we have read of senior US defense officials and Congress encouraging joint development of operational weapons systems. Based on Dr. DeLauer's criteria for assessing the worth of joint programs, the augmentor wing derivative tactical airlifter is, conclusively, a strong contender for cooperative international development. Up front, it meets military needs and it is economically and politically practical.

Two approaches to the tactical airlifter are possible. One is to develop a modern augmentor wing version of the C-130 (and Transall). The other is to develop an all new augmentor wing tactical airlifter. Either program could follow a flight demonstrator phase, as described in Chapter V, or proceed directly to the first production aircraft to be flight test articles and operational "prototypes." The conversion of current production aircraft might be the more economical short term path, and could have a spin-off program to retrofit current fleets. The apparent economic advantages of this option would be offset by the inability to develop a larger cargo area, or to advance the engineering, systems and maintainability to levels appropriate to a 21st century design. It is not the purpose of this paper to choose which tactical airlift solution to pursue, but to point out the advantages of the augmentor wing technology in any desired solution.

The Future Large Aircraft is another opportunity for North American and European NATO military allies to join in a major aerospace development with the potential for significant improvement in interoperabiity and logistics support. More importantly, collaborative defense development efforts are more likely to stimulate higher levels of allied defense spending because of the direct benefits to each country's own economy and job market.

NOTES

CHAPTER VI

[1]*FY 1987 Report of Secretary of Defense Caspar W. Weinberger to Congress*, 241.

[2]*Ibid*, p. 241.

[3]Recently, De Havilland examined a tilt wing aircraft for United States Navy carrier operations. Canadair successfully developed and demonstrated the tilt wing CX84 (a forerunner of JVX) in the mid 60s. See for example, R.D. Hiscocks, "Aircraft Design in Canada from Silver Dart to Challenger and Dash 8," in *Canadian Aeronautics and Space Journal*, 30(2) (June 1984), 110.

[4]D.C. Whittley and P.R. Sully. "Recent Developments in Powered Lift Technology," presented to the 1985 Defence Science Symposium, Ottawa, Ontario, Canada, November 19-20, 1985, p. 6.

[5]Whittley and Sully, p. 7.

[6]*Ibid*.

[7]Richard D. DeLauer. "Blending Technologies & Management into Joint Combat Effectiveness," *Defense 84*, July, p. 8.

[8]*FY 1987 Report of Secretary of Defense Caspar W. Weinberger to Congress*, 270.

[9]DeLauer, pp. 8-9.

CHAPTER IV

TECHNOLOGY AND DESIGN FEATURES

Under the auspices of Aeronautics Systems Division (ASD), the Air Force Laboratories at Wright-Patterson Air Force Base (AFWAL) are examining Advanced Tactical Transport Technologies (ATTT), in a study by that name, applicable to the Tactical Mobility Mission Analysis (TMMA) for an Advanced Tactical Transport (ATT) as described in Chapter II.[1] The technology interests cover the spectrum of operational concerns expressed in the preceeding chapters; however, for the purposes of this paper the focus here will be on aircraft design - specifically the application of Canadian Augmentor-Wing (AW) technology to tactical airlifters.

ADVANÇED TACTICAL TRANSPORT TECHNOLOGIES (ATTT).

The USAF technology study takes the critical mission - the resupply of troops behind the Forward Edge of the Battle Area (FEBA) or behind the Forward Line of Own Troops (FLOT) with an assault payload of 27,000 lbs. - as its baseline. In one representative regional or internal intratheater scenario a light brigade (5-6,000 troops and equipment) is to be moved 2 to 3,000nm in 6 hours. The specified range is 2000nm on a 4g aircraft, or 3,000nm on a 2.17 to 3.12g aircraft. Terrain following and terrain avoidance systems and procedures will require the design to withstand the stress loads of 30 degree weaves at 300ft AGL requiring 2.5 to 3 or perhaps 4 g.[2]

Two aircraft research, or "test", designs have been selected to represent the technology spectrum which will be examined before choosing a final developmental design. In each case the C130 "box" capacity (9ft. high x 10.25ft. wide x 41ft. long), which is capable of lifting a Blackhawk helicopter and other field weapons, has been retained.

SURVIVABLE VERTICAL/SHORT TAKE OFF AND LAND (VSTOL)
LOW RADAR CROSS SECTION DESIGN.

In what is referred to as a "survivable VSTOL" design, the aircraft would be "optimized" for a low radar cross section [Figures 4-1,2]. Larger than the C-130, its chief features are:

a. Design Gross Weight: 223,000lbs;
b. Two engines of 40,000lbs thrust ea. with a 14:1 bypass; ratio (lower if possible);
c. Wing area: 3,135 sq ft;
d. Aspect ratio: 6.34;
e. Sweep: 35 degrees;
f. Thickness to Chord ratio (T/C) : 14%;
g. Thrust to Weight ratio (T/W) : cruise .36, VSTOL 1.43;
h. Cruise speed: M.8 - M.85;
i. Payload: 27,000lbs;
j. Range: 2,000nm-3,000nm; and
k. STOL: VSTOL(0-300ft.).

This design represents a radical departure from the "baseline" C-130 and its large wing area seems to contradict the design aim of a low radar cross section. Interestingly, it is similar in appearance to the de Havilland Aircraft of Canada (DHC) Supersonic Short Take-Off and Vertical Land fighter (SSTOVL), even to the point of including what appear to be ejector-type lift devices.

SHORT TAKE OFF AND LAND (STOL) DESIGN.

The second design envisioned by Air Force planners is a more conventional-looking STOL aircraft [Figure 4-3]. Its chief features are:

a. Design Gross Weight: 190,000lbs.;
b. Engines: Counterrotating turbo-prop/Unducted Fan (UDF);
c. Wing area: 1700 sq ft;
d. Aspect ratio: 8;

e. Sweep: 16 degrees;
f. T/C: 12% root;
g. Cruise speed: M.6 - M.7 at sea level; and
h. Payload: 44,000 lbs;
i. Range: 3,000nm; and
j. STOL: 1500ft.

The above designs are not definitive, but representative of two alternative approaches which might be capable of satisfying USAF operational requirements. Current developmental targets include:

a. Model fabrication and testing of a 1/16th scale VSTOL model for VSTOL Aero/Propulsion/Control effects in the NASA AMES 7X10 wind tunnel by mid 1987; and
b. A Statement of Requirement for lift-engine data to go to contract by July, 1986 (AFWAL lift-engine work has been with Rolls Royce to date).

USAF PROGRAM OUTLOOK

Approval in principle for a go ahead on a replacement aircraft project will be sought via a Program Objective Memorandum (POM) to be proposed between 1988 and 1990. A demonstration of the validity of the design and concept would follow between 1992 and 1996 with development and production scheduled for 2001. The Initial Operational Capability (IOC) is envisaged in 2002.

CANADIAN FORCES (CF) PROGRAM PLANNING

The CF C-130 fleet will reach the end of its economic life by 2010 (as will many other air forces and operators of civil C-130s). While the CF requirement has not yet been defined, it will likely reflect the combined strategic and tactical nature of tasks to deploy oversized cargo and troops to Europe,[3] in an aircraft approximately the size of a C-130. The CF have been following the progress of the DHC Advanced STOL Transport (AST) [Figure 4-4] with great interest as its predicted performance capabilities compare very favorably with CF requirements.

a. Design Gross Weight: 200,000lbs;
b. Engines: 2 or 3 turboprop or turbofan;
c. Wing area: N/A;
d. Aspect ratio: N/A;
e. Sweep: N/A;
f. T/C: N/A;
g. Cruise speed: M.8 at sea level; and
h. Payload: 44,000-67,000lbs;
i. Range: 4,000nm; and
j. Mid-Mission STOL: 36,000lb. payload in 1,000ft or less.

EUROPEAN PROGRAM PLANNING

The four country industry consortium of Lockheed (USA), MBB (FRG), Aerospatiale (France), and British Aerospace (UK) are collaborating on a European project known as the Future International Military Airlifter (FIMA). Their objective is to define a common specification for a tactical airlifter for the NATO air forces. Compared with a C-130, FIMA could be up to 30 percent heavier, and deliver "useful payloads over long, unrefuelled ranges:"

a. Design Gross Weight: 200,000-230,000lbs.;*
b. Engines: 3 turboprop or turbofan;
c. Wing area: N/A;
d. Aspect ratio: N/A;
e. Sweep: N/A;
f. T/C: N/A;
g. Cruise speed: M.7 - M.8 at sea level;
h. Payload: 44,000-60,000lbs;*
i. Range: "Long, unrefuelled;" and
j. Mid-Mission STOL: "Better than C-130."
* Based on a required 30% improvement over the C-130.

RAF require better STOL performance than the C-130, and a minimum of 3 engines because of operations in a high threat environment. The augmentor-wing technology lends itself to this requirement. Parametric studies of 3 [Figure 4-5] and 4-engined aircraft, for example, have been conducted utilizing either Rolls Royce RB419 or Pratt & Whitney PW2037 engines. Moreover, the engine-out landing and take-off performance of the augmentor-wing aircraft commends it, above all competing technologies, to operations in a potential combat environment. These requirements are generally consistent with Canada and the U.S.

POWERED LIFT FOR STOL

United States Army orders for Beaver, Otter, Twin-Otter, and Caribou STOL aircraft during and since the Korean war gave De Havilland Canada strong support to develop its special capability in producing "rugged, reliable, easy to operate and flexible . . ."[4] STOL aircraft. The Buffalo was also designed for the U.S. Army, but the anticipated large sales[5] were a casualty to the U.S. Army and Air Force agreement which divided the responsibility for fixed-wing (USAF) and rotary-wing (USA) aircraft.

STOL is customarily known to offer field performance at the expense of cruise performance. Augmentor Wing powered lift technology diverts propulsion energy to augment wing lift during takeoff and landing permitting STOL aircraft wings to be designed with little to no penalty to cruise performance.

AUGMENTOR WING POWERED LIFT

The augmentor-wing is an internally blown system which has separate control over the propulsive and blowing components of thrust, and cross-ducting [Figure 4-6] to eliminate roll upset in the event of engine failure [Figure 4-7]. An ejector flap [Figure 4-8] generates high lift which is particularly important for safe and comfortable climb-out with one engine inoperative. The thick supercritical wing [Figure 4-9] is the other key component of the augmentor wing.

In the early days of powered lift few engines could produce the bleed air needed for wing-lift augmentation. Two rival technologies gained the ascendancy: Upper Surface Blowing (USB) and Externally Blown Flaps (EBF). The deficiencies inherent in these two concepts, represented by the YC-14 and YC-15 respectively, became apparent during the Advanced Medium STOL Transport (AMST) competition and led to the termination of the program. Aircraft handling during the loss of the critical engine was judged unsatisfactory in both cases.

INHERENTLY SAFE ENGINE OUT PERFORMANCE

Aircraft performance in the critical engine-out case is one of the significant strengths of the augmentor wing technology.

> "In particular for the twin-engine augmentor wing aircraft which was the subject of this investigation, it should be possible to accomplish a safe landing following an engine failure at any point in the final approach . . ."[6]

This is achieved by cross-ducting in the wing to counter roll imbalance in the event of engine failure. The propulsion/blowing engine provides proper thrust management to cope with these demands, and in particular the ability to perform a go around, or wave-off, without change to flap angle.[7]

PROPULSION SYSTEMS

Early critics of the AW concept decried the need for a new engine to provide ample bleed air for constant wing blowing while forward thrust is being modulated. A unique engine is no longer required. Both Rolls Royce and Pratt & Whitney have based AW proposals on modifications to existing engines. This reduces risk, cost and concern associated with engine development.

De Havilland and Rolls Royce teamed-up to develop the

Split-Flow Spey on the Buffalo Augmentor Wing Research Aircraft (AWRA), and again in planning the three-stream RB419 engine turbofan [Figure 4-10] and turboprop [Figure 4-11] to power C-130-sized aircraft. Recently, De Havilland and Pratt & Whitney joined to propose a derivative C-130 powered by two PW2037 engines [Figure 4-12]. Similar collaborative activities with General Electric (GE) are not known to the author. The GE Unducted Fan (UDF) could be used, but would likely require an Auxilliary Power Unit (APU), or other external source of bleed air.

SUPERCRITICAL WING

A major secondary benefit accrues from the continued use of wing blowing during cruise. Boundary layer control from the blowing air permits thick supercritical wing sections to be flown at high subsonic cruise Mach number. Related benefits of the thick wing are high lift for takeoff without leading-edge devices,[8] reduced structural weight and additional space for fuel. This translates directly into improved field performance, longer ranges and more flexible payload/range combinations.

AW TECHNOLOGY APPLICABILITY

The striking feature of the AW technology is how well it meets the needs of the air forces planning new tactical airlifters and special operations aircraft.

a. Design Gross Weight: nominally 180-230,000lbs;
b. Engines: 2, 3 or 4 turboprop or turbofan;
c. Cruise speed: M.8 at sea level; and
d. Payload: 44,000-67,000lbs;
e. Range: 4,000nm;
f. Mid-Mission STOL: 36,000lb. payload in 800-1,000ft;
g. VSTOL: parametric studies done for the USN show vertical take-off achievable with a tilt-wing and excellent productivity using a short, or ramp take-off and vertical landing.

The chief performance benefits of the AW technology relate to control stability (no roll) in engine-out case, and virtually no Minimum Control Speed Air (V_{MCA}). Safe and responsive critical engine-out go-around [Figure 4-13], without raising flaps, and critical engine-out takeoffs. The thick wing provides more fuel capacity with greater inherent operational flexibility to interchange payload for fuel (range) or vice versa, high subsonic cruise Mach, and improved lift on takeoff without leading edge devices. Routine ground rolls would be in the order of 800 to 1,000ft [Figure 4-14] with planned payloads and shorter when empty. The technology can be extended to a tilt-wing design for vertical takeoff and landing with low to moderate risk by capitalizing on the thick wing and cross ducting. The engine-out case, field performance, cruise and payload/range performance technology requirements of the next generation of tactical airlifters, including ATT & FIMA, are within the capabilities of the Canadian/DHC powered lift technology.

SUMMARY

The Augmentor-Wing Powered Lift technology as a candidate advanced tactical transport technology affords a solution to known USAF, European, Australian and Canadian requirements. Marketing surveys conducted under the auspices of the Canadian Government show interest in a number of other countries. The DHC technology affords flexibility in choice of propulsion system and primary mission vehicle. Parametric studies have been done for two, three and four-engined aircraft[9] ranging from a re-winged, re-engined C-130 at 180,000lbs. to all new aircraft between 220,000 and 500,000lbs. While the strategic ranged aircraft will be briefly reviewed, the tactical airlift projects of interest which will be examined in succeeding chapters are:

a. Modified C-130 technology demonstrator;
b. Modified C-130 production aircraft - (C-130PL); and
c. New design tactical airlifter.

NOTES

CHAPTER IV

[1]Negotiated Request For Proposal (RFP) 85 Jul 16, Solicitation No. F33615-85-R-0116, Requisition/Purchase No. FY7615-85-01118.

[2]This would approximate some of the maneuvers used by the C-130 which evaded the MIG-21, as discussed in Chapter II.

[3]Report of the Special Committee of the Senate of Canada on National Defence, The Honourable Paul C. Lafond, chairman. Ottawa: Queen's Printer for Canada, Issue No. 2, May 2, 1985, p. 2:9.

[4]J.W. Sandford reviewing De Havilland's aircraft development history in Canadian Aeronautics and Space Journal, 25(4) (Fourth Quarter 1979), 321;

[5]Ibid, 326; and R.D. Hiscocks. "Aircraft Design in Canada From Silver Dart to Challenger and Dash 8," Canadian Aeronautics and Space Journal, 30(2) (June 1984), 110.

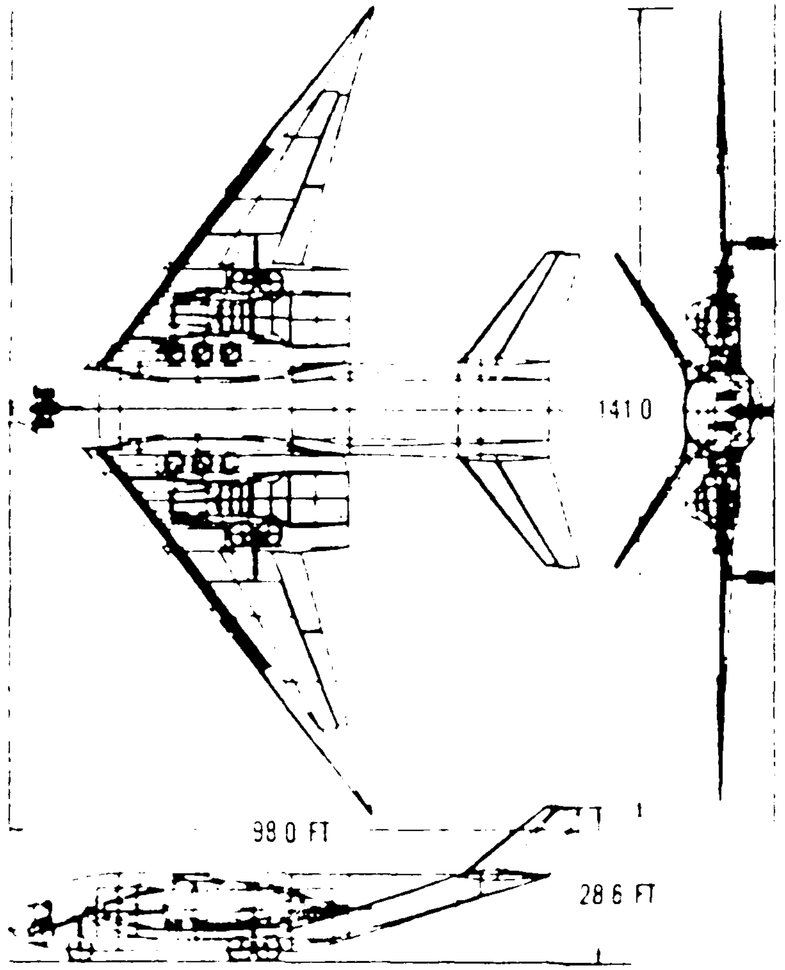
[6]D.E. Sattler, M. Sinclair, S. Kereliuk and R.H. Fowler. "An Investigation of the Recovery from an Engine Failure in a Twin Engine Augmentor Wing Aircraft Using the NAE Airborne Simulator," Canadian Aeronautics and Space Journal, 27(1) (First Quarter 1981), 39.

[7]The advantages of the augmentor wing were briefed to representatives of Air Force Systems Command on June 18, 1985, Military Airlift Command, TRADOC and 23rd Air Force Headquarters on June 20, 1985, and USAF Headquarters on March 27 (including JCS) and June 21, 1985.

[8]DHC-DITC 84-9. Appendix to an unpublished "Test Report on a 3-D Compound Wing Model (WT-CM) in the NAE 30 x 30 Foot Low Speed Wind Tunnel," December 1984, p. 7.

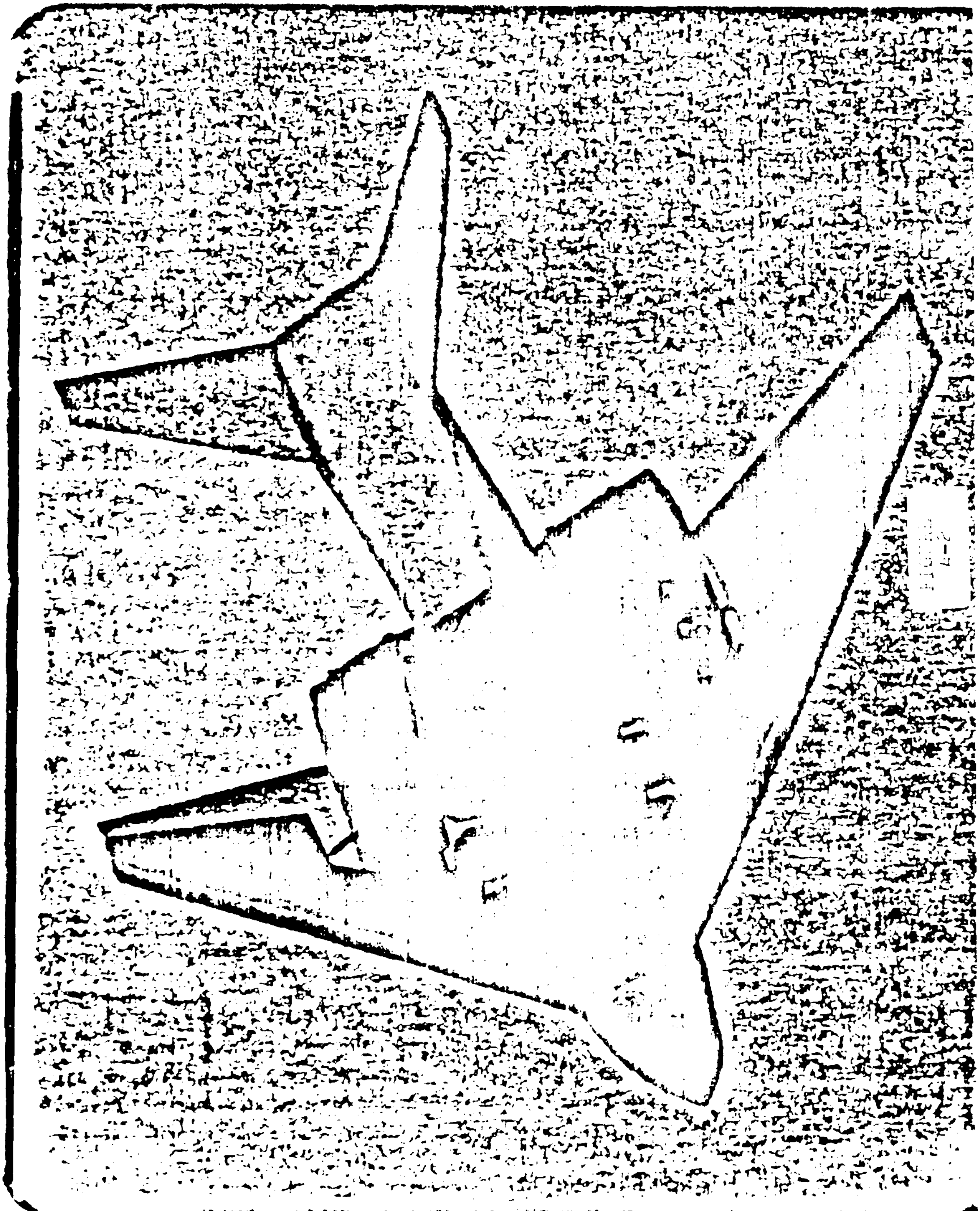
[9]D.C.Whittley. An Update of the Canada/U.S.A. Augmentor-Wing Project, Report to the 54th Meeting of the Fluid Dynamics Panel Symposium on Improvement of Aerodynamic Performance through Boundary Layer Control and High Lift Systems, Brussels, Belgium, May 21--3, 1984 (Neuilly-Sur-Seine, France: Advisory Group for Aerospace Research and Development (AGARD), North Atlantic Treaty Organization, 1984).pp. 4-5.

SURVIVABLE VSTOL
GENERAL ARRANGEMENT

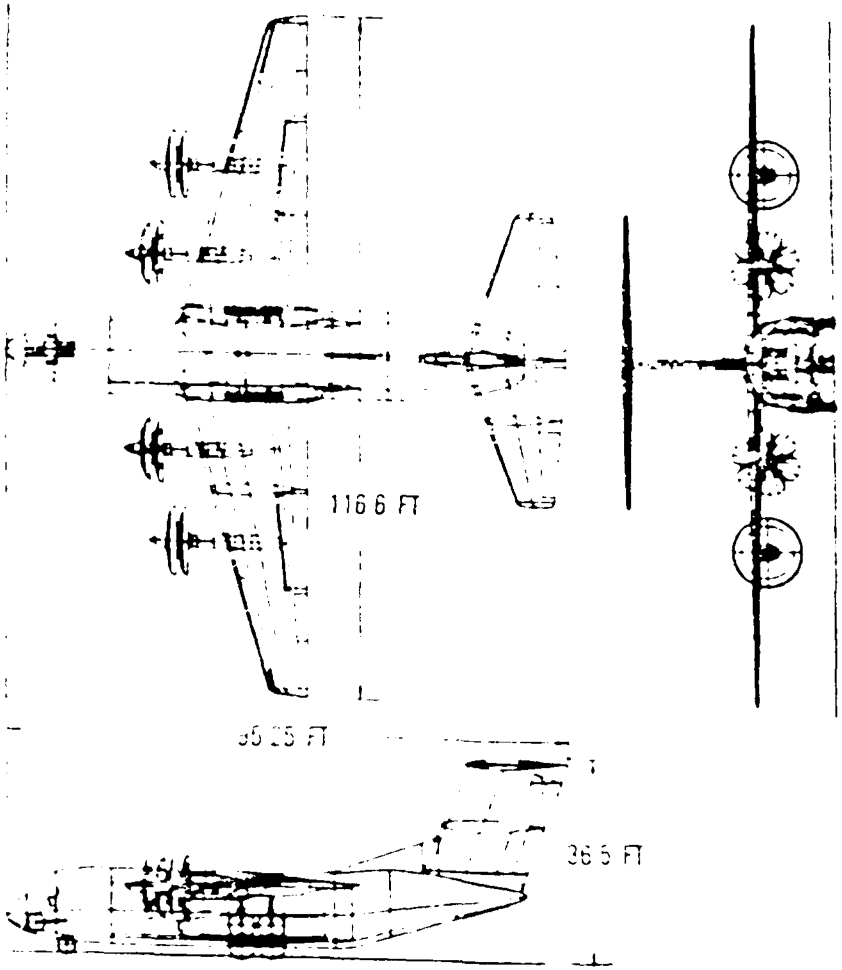


TOGW	223,200 LB
PAYLOAD	36,000 LB
OWE	117,698
ENGINE THRUST	
(2) CRUISE @ 4[illegible],000 LB EA	
(6) LIFT @ 40,000 LB EA	
AIRCRAFT T W @ TOGW	
CRUISE	36
VSTOL	1 43
WING DATA	
REF AREA	3135 SQ FT
ASPECT RATIO	6 34
SWEEP (L E)	35 0 DEG
T.C RATIO	14 0%
BOX SIZE	
HEIGHT	9 00 FT
WIDTH	10 25 FT
LENGTH	41 00

FIGURE 4-1



STOL
GENERAL ARRANGEMENT



TOGW (MAX)	190,000 LBS
PAYLOAD	44,000 LBS
FUEL	58,000 LBS
OWE	90,000 LBS
PROPULSION	
(4) 10,000 SHP TURBOSHAFT	
W 12 FT 6 X 6 CR PROPS	
AIRCRAFT T/W @ TOGW	.5
WING DATA	
REF AREA	1700 SQ FT
ASPECT RATIO	8.0
SWEEP (L.E.)	16 DEG
T/C (ROOT)	12 %
BOX SIZE	
HEIGHT	9.00 FT
WIDTH	10.25 FT
LENGTH	41.00 FT

FIGURE 4-3

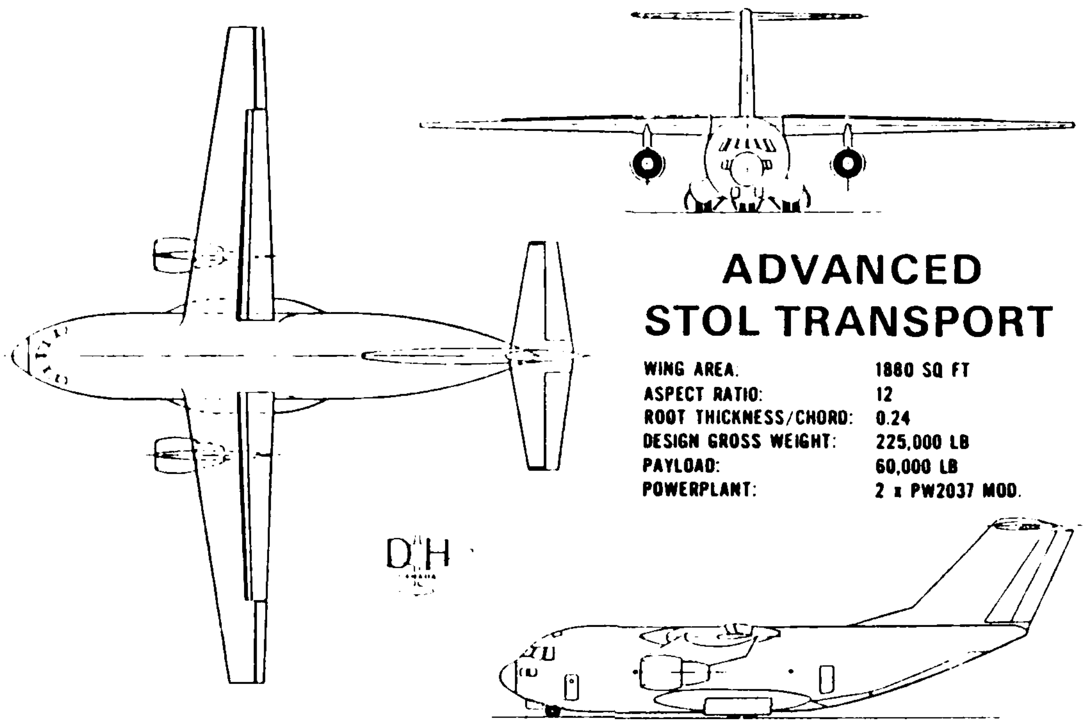

ADVANCED
STOL TRANSPORT
WING AREA: 1880 SQ FT
ASPECT RATIO: 12
ROOT THICKNESS/CHORD: 0.24
DESIGN GROSS WEIGHT: 225,000 LB
PAYLOAD: 60,000 LB
POWERPLANT: 2 x PW2037 MOD.

FIGURE 4-4

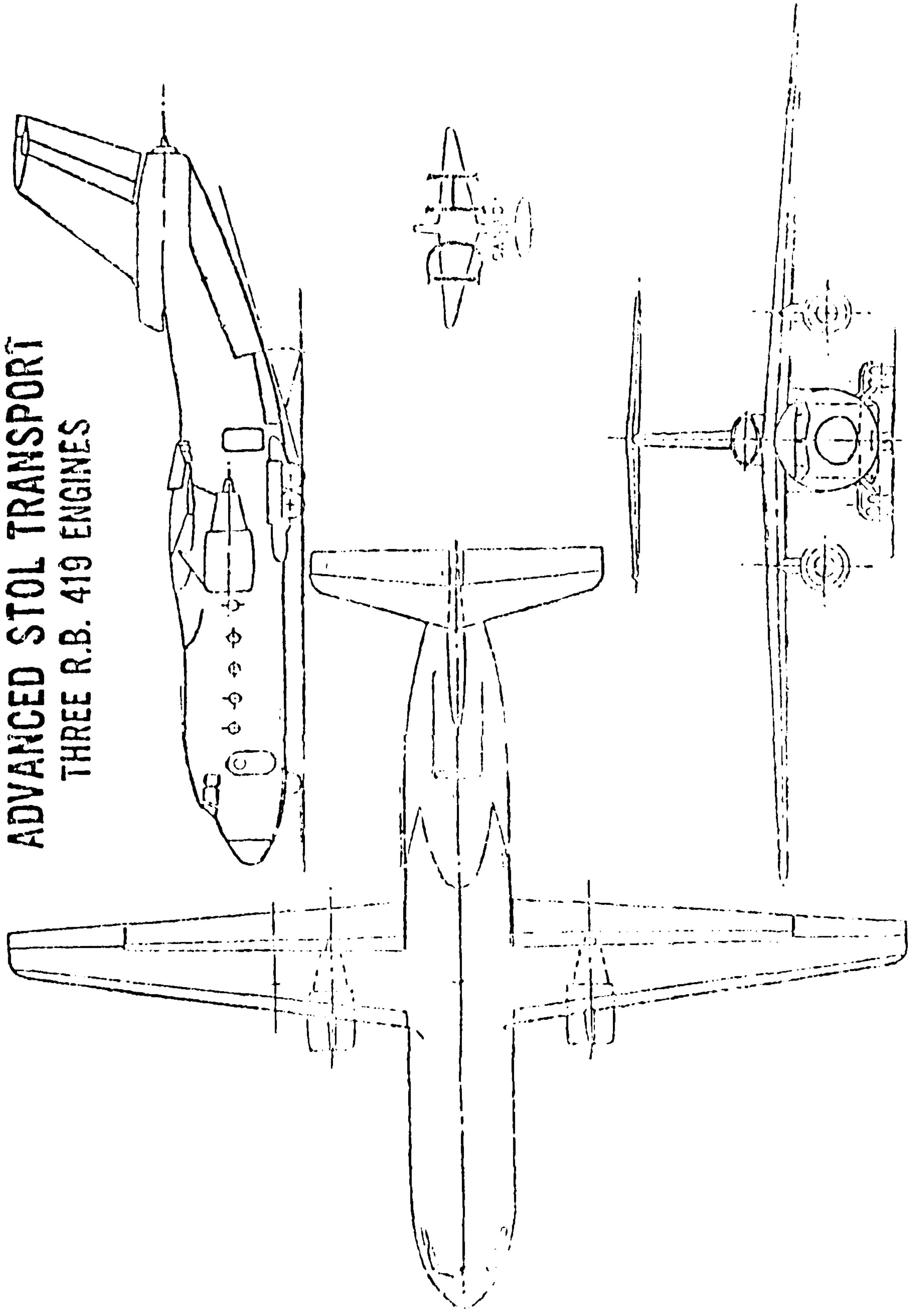
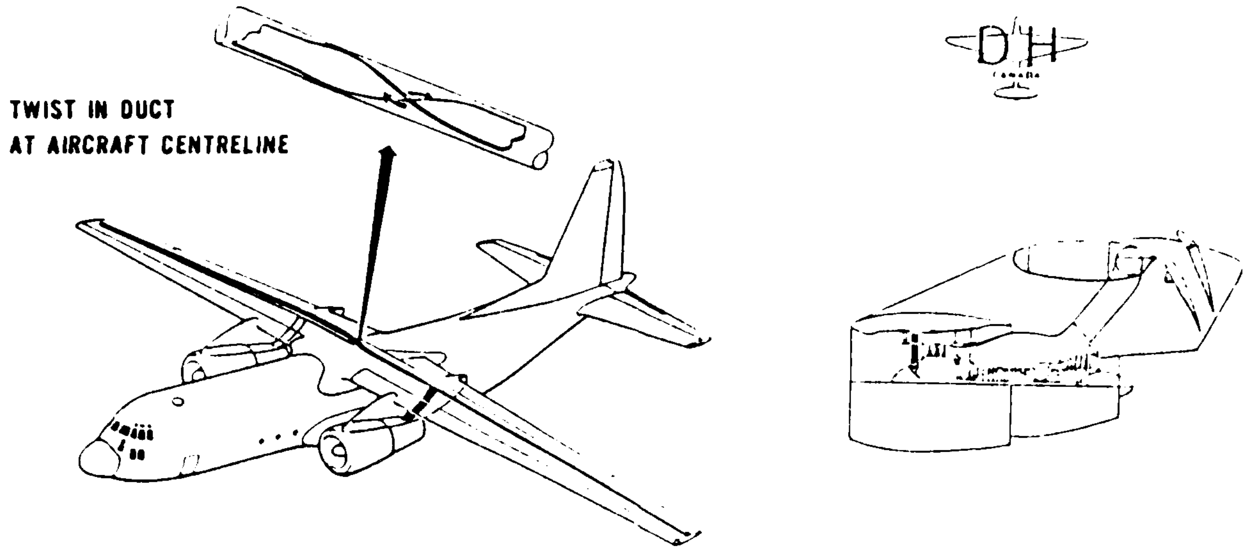


Figure 4-5.

CROSS-DUCTING SCHEMATIC



BLOWING AIR DISTRIBUTION
(ONE ENGINE INOPERATIVE)

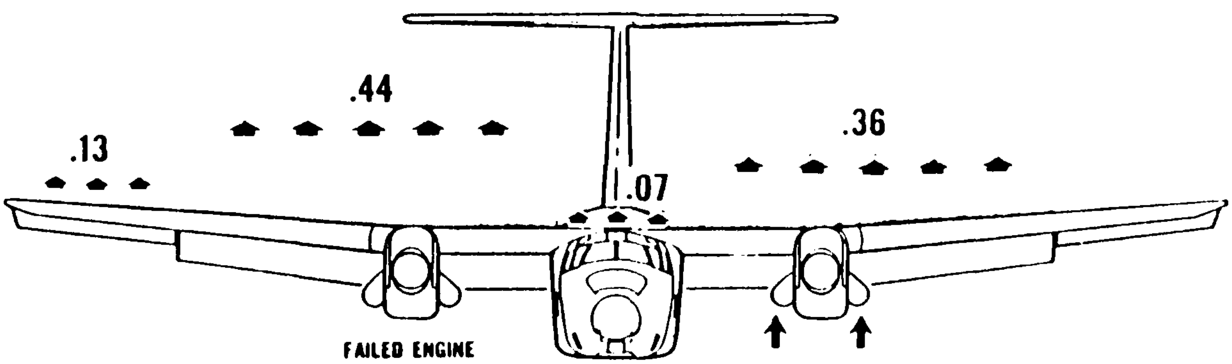
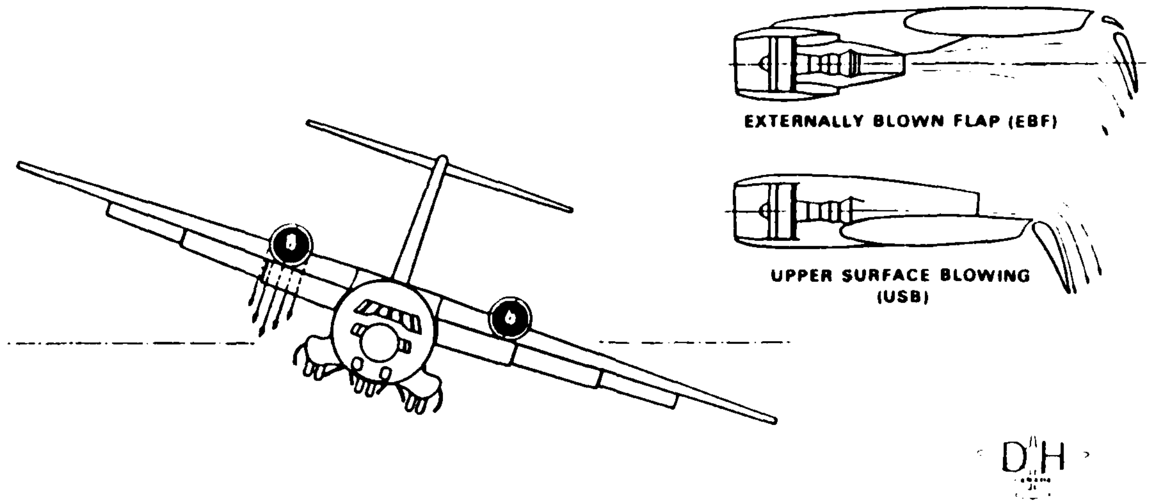


FIGURE 4-6

ROLL UPSET WITH POWERED LIFT*

-- ENGINE FAILURE ON APPROACH --



*NOTE: THE AUGMENTOR WING PREVENTS THIS CONDITION FROM OCCURRING.

FIGURE 4-7

EFFICIENT BLOWN WING
WITH EJECTOR FLAP FOR STOL
(STATIC THRUST AUGMENTATION APPROXIMATELY 1.5)

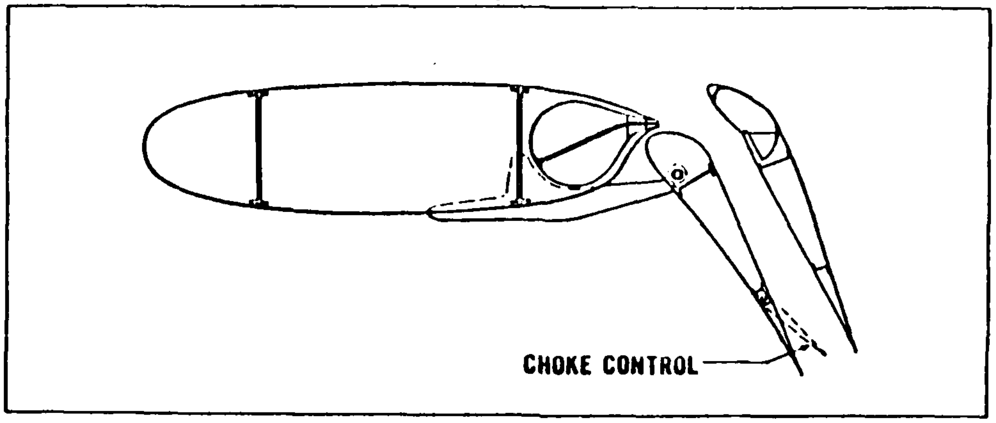


FIGURE 4-8

SUPPRESSION OF FORM DRAG
DUE TO ANGLE OF ATTACK AND WING THICKNESS

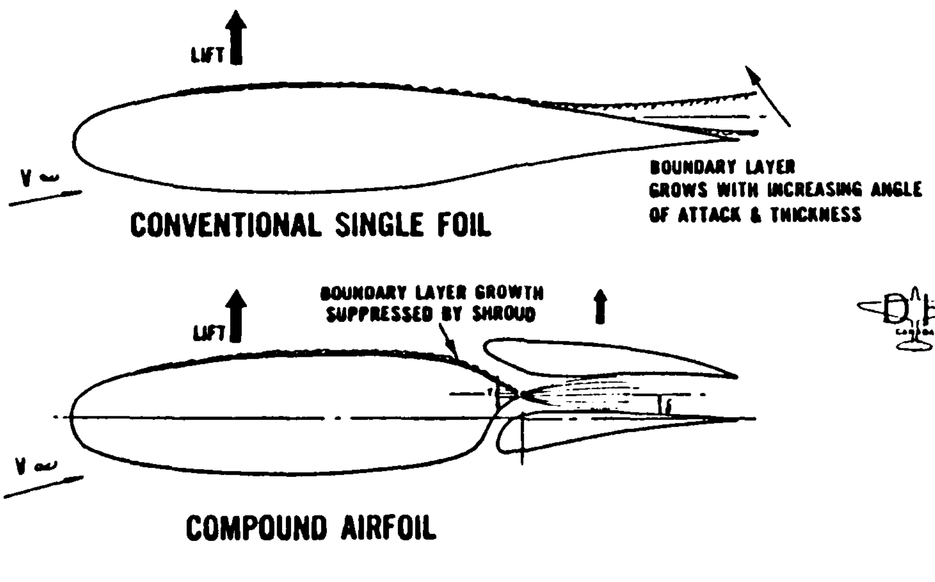


FIGURE 4-9

The de Havilland Aircraft of Canada

ROLLS-ROYCE RB419 PROPULSION/BLOWING ENGINE

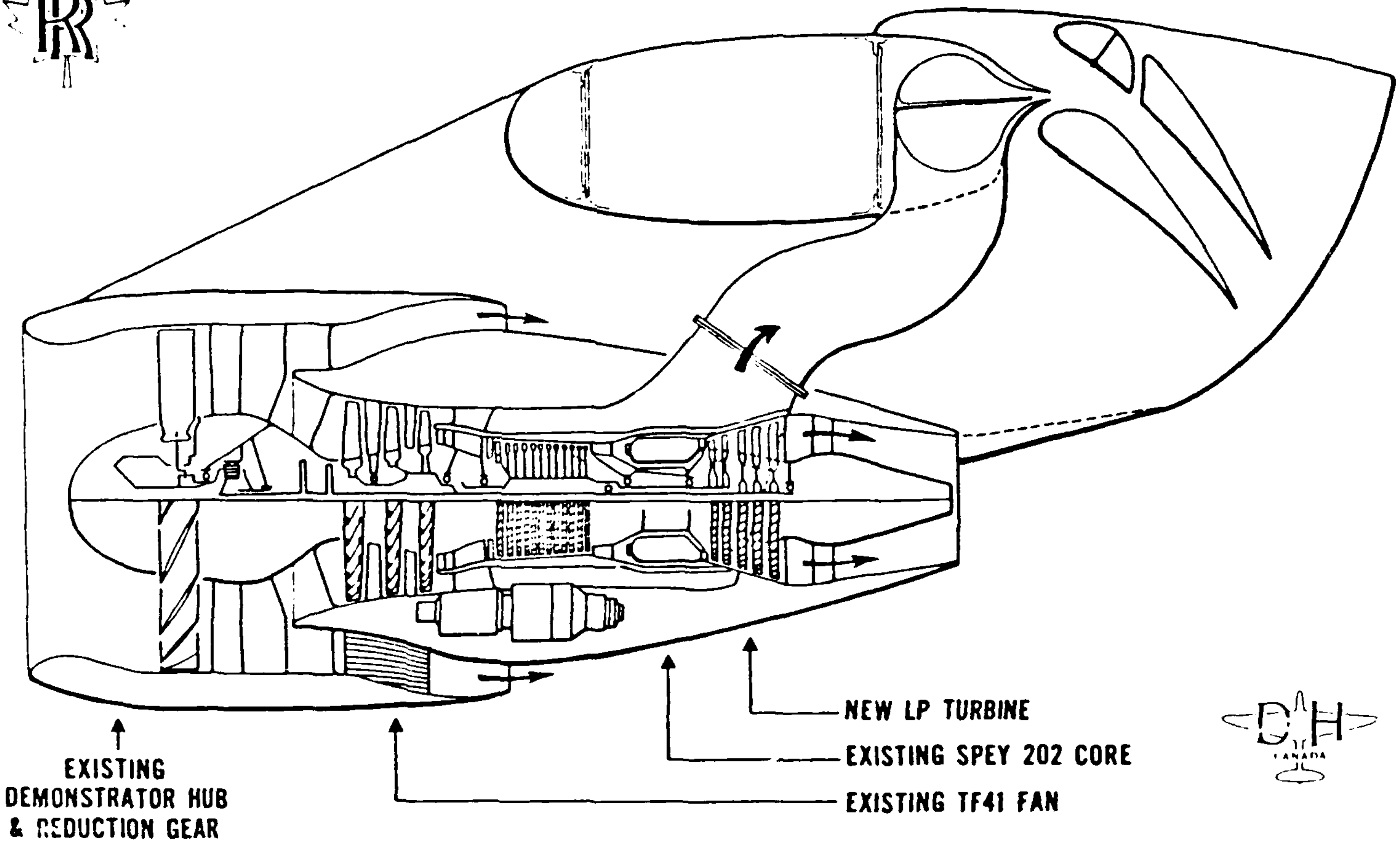
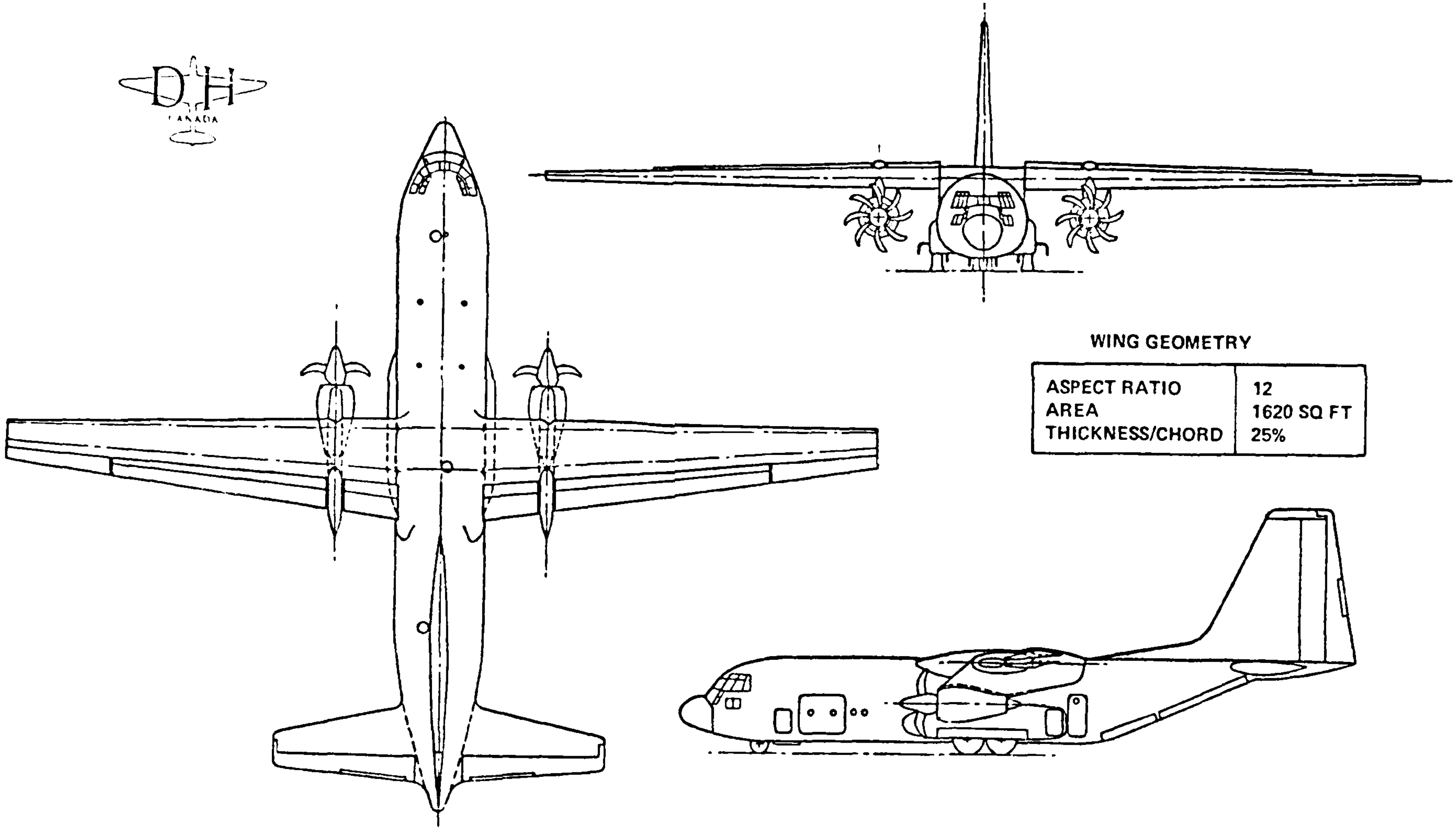


Figure 4-16

DE HAVILLAND POWERED LIFT CONVERSION OF LOCKHEED C-130

TURBOFAN/PROP VARIANT-ROLLS-ROYCE RB 419-03 P



WING GEOMETRY

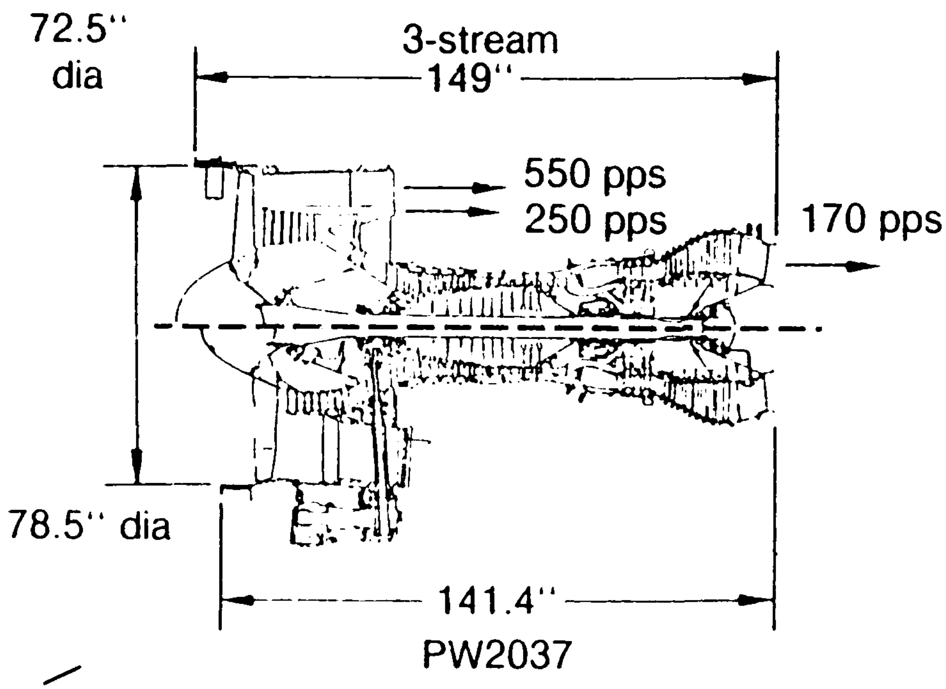
ASPECT RATIO	12
AREA	1620 SQ FT
THICKNESS/CHORD	25%

FIGURE 4-11

PW2037 3-STREAM DERIVATIVE

80% commonality with C-17 and B-757 engines

3



- Increased flow LPC
- New inlet case with variable DIGV's
- Reduced flow/diameter fan
- Front rotor, bearing, control adaptations

FIGURE 4-12

AV297816 851206 1584B

THRUST MANAGEMENT FOR WAVE-OFF

- ALL ENGINES
- 60% POWER LEVEL
- BLOWN FLAP FOR HIGH LIFT (LOW SPEED)
- MODULATE LIFT AND/OR DRAG FOR GLIDESLOPE TRACKING

- ONE ENGINE OUT
- MAXIMUM POWER ON LIVE ENGINE(S)
- BLOWN FLAP FOR HIGH LIFT (WING LIFT RETAINED OEO)
- CONTROL ROLL/YAW/PITCH DUE TO THRUST ASYMMETRY

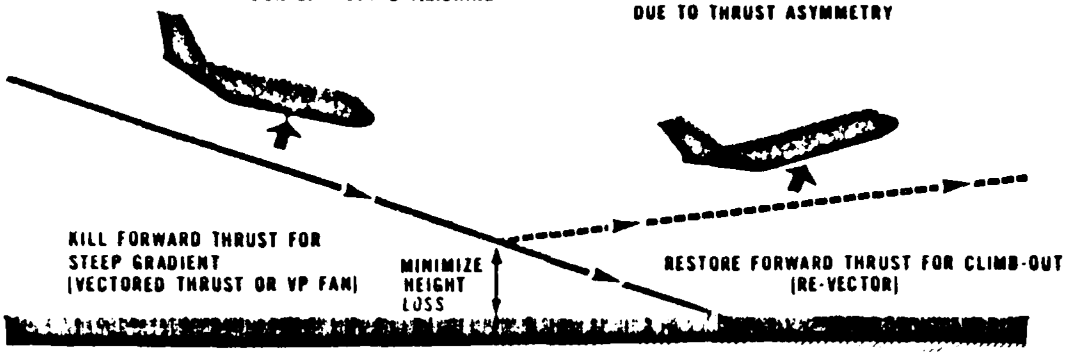


FIGURE 4-13

C-130 PL LANDING PROFILE – "NO FLARE" TECHNIQUE

2 PW PROPULSION BLOWING ENGINES

REMOTE BASE WEIGHT = 153,000 LB

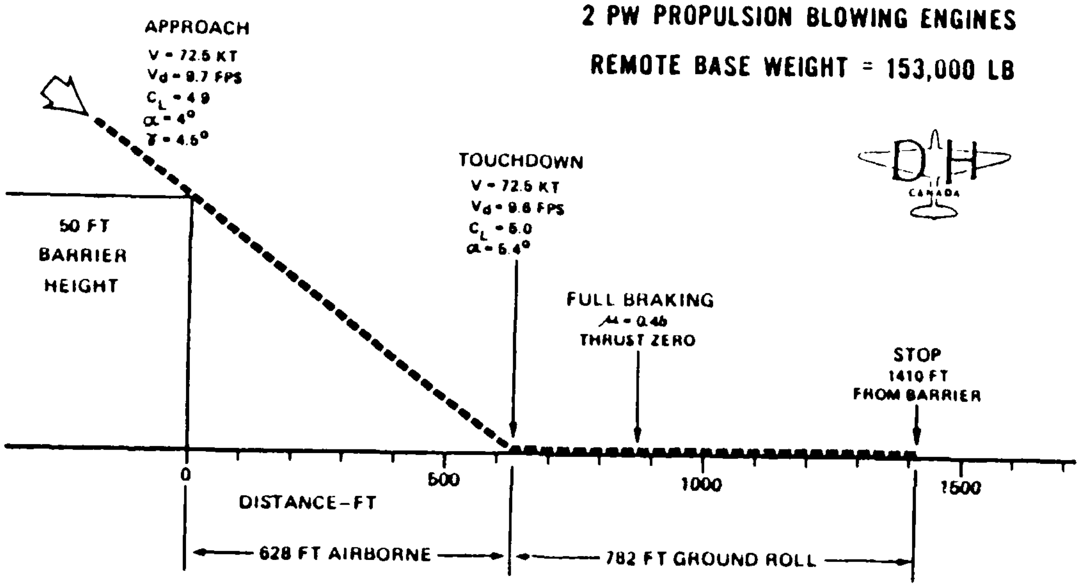


FIGURE 4-14

CHAPTER V

TECHNOLOGY DEMONSTRATOR AIRCRAFT

U.S./CANADA DEVELOPMENT SHARING - BACKGROUND

This chapter assumes an eventual US/Canada collaborative program for a flight demonstrator aircraft. The history of U.S./Canadian defence co-operation dates back to 1941 and the Hyde Park Declaration which dealt with the mobization of each country's defense industrial base to support the war effort. In 1963, a Ministerial "Memorandum of Understanding in the Field of Cooperative Development," superseded earlier agreements with the individual U.S. services. This change was precipitated by the transfer of large-scale Research and Development (R&D) from the Department of National Defence to the Department of Industry following the cancellation of the CF-105 Arrow fighter.[1]

In the United States the USAF has the research, development and production responsibilities for its own weapons systems. In Canada, those responsibilities are now divided between the Department of National Defence (DND) which funds a minor share of R&D projects in support of its defined requirements, and the Department of Regional Industrial and Economic Expansion (DRIE) which sponsors large scale national R&D projects. While both departments have funded, and continue to fund, augmentor wing research, DRIE is responsible to lead the development until it meets DND specifications, at which time DND would commit funds for its portion of the production. Steps are in progress for the Chief Research and Development (CRAD) within DND to become more active in defence research and development leading to production, and in Augmentor Wing R&D in particular.

C-8B BUFFALO AUGMENTOR WING RESEARCH AIRCRAFT (AWRA)

In 1970, the then Department of Industry and the National Aeronautics and Space Administration (NASA) supported a De Havilland Aircraft of Canada Limited (DHC) project for flight research into enhanced Short Take-Off and Land (STOL) through Augmentor Wing (AW) technology.[2] The flight research vehicle was a DHC C-8B Buffalo.[3] The jet engine and blown augmentor flap wing modifications were completed by Boeing in Seattle. Flight testing was at NASA Ames, California, with a brief follow-on session at the Mountain View airfield near Canadian Forces Base Trenton, Ontario. That early research verified wind tunnel data and proved the field and engine-out performance enhancements of an augmentor-wing jet-engined transport aircraft. In the course of testing, the AWRA has been flown by representatives of all US services, the RAF, CF and by Canadian and US civilian pilots from national aerospace agencies and industry (Lockheed-Georgia). The handling characteristics are impressive and, perhaps, best expressed by an RAF test pilot with extensive experience flying transports and Harriers. Following his third sortie he began experimenting with the controls to exploit the AWRA's performance potential. His report concluded that the handling characterisitcis were comparable to a Harrier, thus he was very comfortable with the aircraft when making slow speed precision landings, approaches, go-arounds, and landings with a simulated engine failure, for example.[4]

PHASE A STUDIES

By 1981 the AWRA had accumulated data from over 700 hours of test flying. The next step was to consolidate the technology and determine the most appropriate market segment on which to focus future development. Before settling on the C-130 sized aircraft, parametric studies matched the AW technology with Short Take Off and Land (STOL) and Vertical/Short Take Off and Land (VSTOL) aircraft in a variety of navy and air force roles: Carrier On-Board Delivery (COD), Antisubmarine Warfare (ASW), Airborne Early Warning (AEW), twin-engined tactical airlifters from 100,000 to 230,000lbs. design gross weight, and three and four engined aircraft weighing up to 500,000lbs (including AW versions of the YC-14 and YC-15). While the AW technology proved to be compatible with all of these, De Havilland's business decision was that the biggest potential market, and the greatest immediate interest, lay in the C-130-sized tactical airlifter. This conclusion was consistent with Canadian Forces requirements for more intra-theater aircraft capable of lifting over-sized cargo over strategic ranges:

> "Further, Canada's reinforcement capability with respect to our European-based and -assigned forces is clearly inadequate."[5]

Market surveys by the Canadian Government and De Havilland and specialist consultants have shown the viability of an Augmentor Wing follow-on to the C-130, as well as to a range of other aircraft applications. Discussions with potential industrial partners have received courteous but cautious responses, in a fiscal climate which does not seem ready to support the new "approved" C-17 strategic airlifter let alone a new tactical airlifter. Lockheed-Georgia which has had a Memorandum of Understanding with De Havilland for the exchange of data on this technology has felt, perhaps, the greatest need for caution in this area because of its successful windfall sale of C-5Bs as an unexpected prelude to the C-17 start up. Yet, Lockheed could have the most to gain with the potential to appeal to the widest possible customer base through retrofit of current C-130s, new sales of C-130s modified on the production line and an all-new design Advanced Tactical Transport. Of course, it is not essential that Lockheed be involved in either the retrofit or the new-design projects.

PHASE B STUDIES

During Phase B, aircraft and engine configuration and systems design will be finalized. Drawings produced in this phase will be sufficiently detailed to permit demonstrator aircraft to be built-to-print, once the go-ahead is given for Phase C. The scope of Phase B will include:

a. Internal and external configurations;
b. Systems and flight controls;
c. Development of three-stream version of the PW2037;
d. Nacelle, pylon and engine installation definition;
e. Wind tunnel testing of C-130 demonstrator configuration;
f. Performance target confirmation;
g. Development of specific hardware components (e.g., flap, nozzle and ducting);

Phase D is an 18 month program of joint airframe and engine design and development. The cost of the development work preparatory to the conversion of a demonstrator is estimated at \$15M for the airframe and \$25M for the engines (1985 Canadian dollars)

PHASE C - DEMONSTRATOR CONVERSION

Phase C will comprise the conversion and flight evaluation of the demonstrator. Two hundred hours are planned for flight testing.

Rolls Royce Demonstrator Engine

Rolls Royce Canada collaboration with De Havilland culminated in a 1984 proposal to develop an engine for the demonstrator (RB 419-03), combining the Spey 202 core with an Allison TF41 intermediate compressor. An RB419 powered demonstrator would show performance advantages over the C-130 in cruise (M.7), field performance (T/O and Landings in <1000ft), and full payload range (approximately 2,500nm). Rolls Royce also offered a turboprop version of its RB 419 with a somewhat slower cruise speed in the order of M.6 or M.7. Rolls Royce completed their program proposal in 1984. A Rolls Royce powered augmentor wing aircraft might have particularly strong appeal to the RAF and the European consortium. While the proposal for a demonstrator was based on a twin-engined aircraft, the technology permits a production aircraft being powered with 3 or 4 turbofan or turboprop engines, if required.

Pratt & Whitney Demonstrator Engine

The USAF team which audited the AW technology recommended De Havilland consider US engine manufacturers as potential partners. Pratt & Whitney were first off the mark and proposed a derivative of their PW2037 engine [Figure 5-1] which is currently in airline service with a military version slated for the C-17. The commercial PW2037 is proving to be a highly reliable engine, and the military version is expected to be equally reliable. Pratt & Whitney estimate that the AW engine would have 80% compatability with the C-17 [Figure 5-2]. Since the PW2037 powered AW C-130 [Figure 5-3] met the requirements of the USAF technology audit team, it was selected as the baseline for the demonstrator program [Figure 5-4].

PHASE C - PROGRAM AND COSTS

The Phase C Demonstrator Program would cover a 30 month period. The costs are estimated at $90M for the airframe modification, assembly and contractor flight trials, $70M for three experimental flight engines, $14M for a basic C-130 airframe, and $16M for flight trials at a government facility, for a total of $190M (US 1986). A program cost in the order of $200M, or $100M per partner, is not excessive in the aerospace industry; however, even this cost could be reduced further through the provision of existing hardware and facilities: a used C-130E, test facilities at Edwards Air Force Base, Canadian Forces Base Cold Lake, NASA Lewis, NASA Ames, and Arnold Engineering Development Center, for example.

SUMMARY

The AW Demonstrator project is a means of proving the concept with a flight vehicle which is well known to and respected by tactical airlift operators, and which approximates the characteristics envisaged in an Advanced Tactical Transport (ATT). It is not intended that a demonstrator would freeze the design for any particular developmental or production aircraft. The AW demonstrator program has these unique features. First, it could be bypassed since the technology is sufficiently mature to proceed directly to production-model prototyping of inventory or assembly line C-130s, or a new design. Second, the demonstrator could preceed the retrofit or assembly line C-130 modifications, or a new design airlifter program. Third, the demonstrator could be used to extend the Augmentor Wing Advanced technology into the Vertical Short Take-Off and Land (VSTOL) or Short Take Off and Vertical Land (STOVL) regimes.

Until a decision is taken for a production model Augmentor Wing airlifter, a demonstrator program should be pursued as a priority means of exploiting the technology while awaiting the proper climate to fund development and production. The Canadian offer to underwrite fifty percent of the $200M cost of a demonstrator program should commend itself to the USAF, DOD, and to the Congress each of whom will face increasing fiscal pressure, hence difficulty funding the many defense projects competing for scarce capital. Moreover the opportunity to share the cost of a major defense production program with a single partner,or coalition, in the near-term should be an attractive alternative to the potential for indefinite program deferral if relying on purely national priorities and domestic funding. The time for a joint program is now.

NOTES

CHAPTER V

[1] United States-Canada Defence Development Sharing Program, and United States-Canada Defense Production Sharing Program, External Affairs Canada pamphlets explaining the historical authority and current United States policies and mechanisms for joint development and production. For more on the CF-105 Arrow see footnote 9 at Chapter I.

[2] DHC has earned a reputation for producing world class STOL aircraft highly suited for tactical airlift and special operations. It is natural that they would strive to develop a technology combining the jet engine, and high speed cruise performance with STOL to enhance productivity and cost-effectiveness.

[3] Developed for the United States Army as a follow-on to the C-7 Caribou, a large sale of these aircraft to the Army was about to be concluded when the deal fell victim to the United States Army/United States Air Force agreement which allocated rotary-winged aircraft to the Army and fixed-wing aircraft to the Air Force.

[4] Flight Lieutenant T. Brown, RAF from Boscombe Down in a report on his five sorties in the AWRA in 1982.

[5] Thomas d'Aquino. "National and International Security -- A Forgotten Priority: A Business Council Perspective on Canadian Defence Policy," From the text of an Address to the Conference of Defence Associations, Ottawa, January 10, 1985, p. 5.

PW2037 3-STREAM DERIVATIVE

Retains core & LPT of Commercial/C-17 powerplants

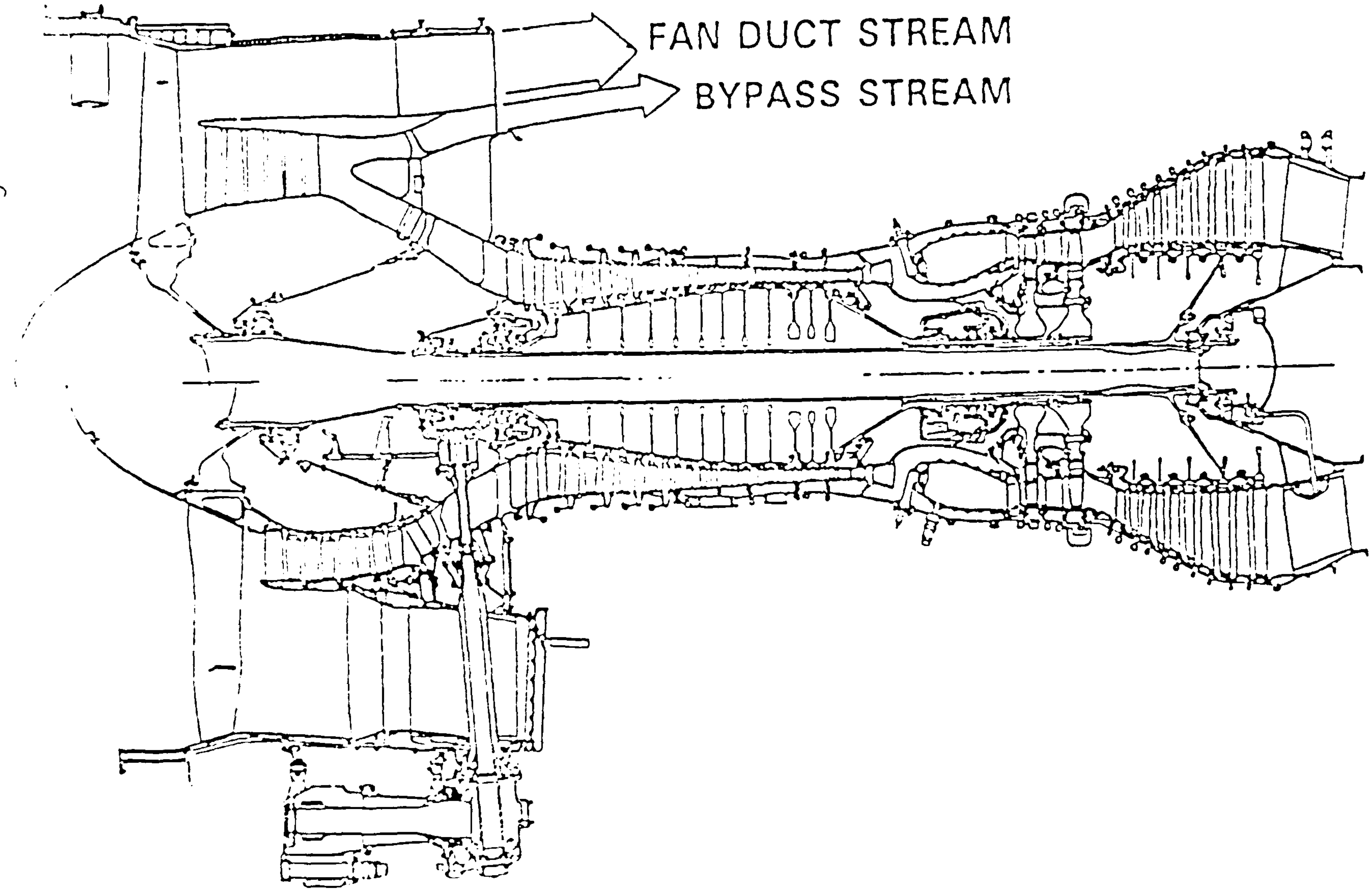


figure 5-1

2

SUMMARY

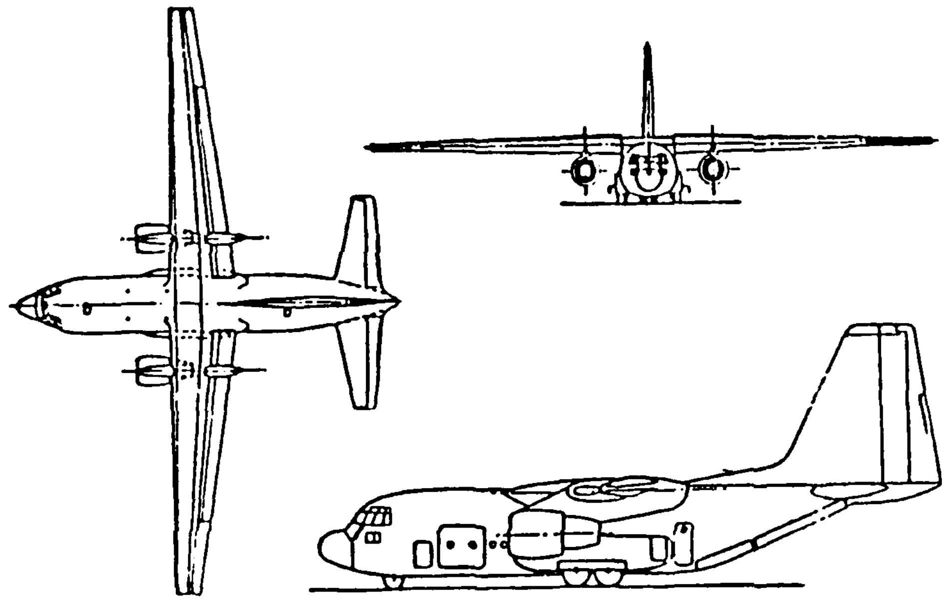
- Exceeds C-130 PL requirements
- Retains 80% commonality with PW2037
- Development/production program defined
- PW2037 will have been in service 10 years when 3-stream derivative certified

FIGURE 5-2

AV297823 850506 1579B

C-130 STOL

Powered Lift Provides Significantly Enhanced C-130 Performance



- o 30% Cruise Speed Increase
- o 1000 Ft. Ground roll or Less
- o Reduced Radar Signature

- o New Augmented Wing
- o 3-Stream PW2037 Derivative Engine

FIGURE 5- 3

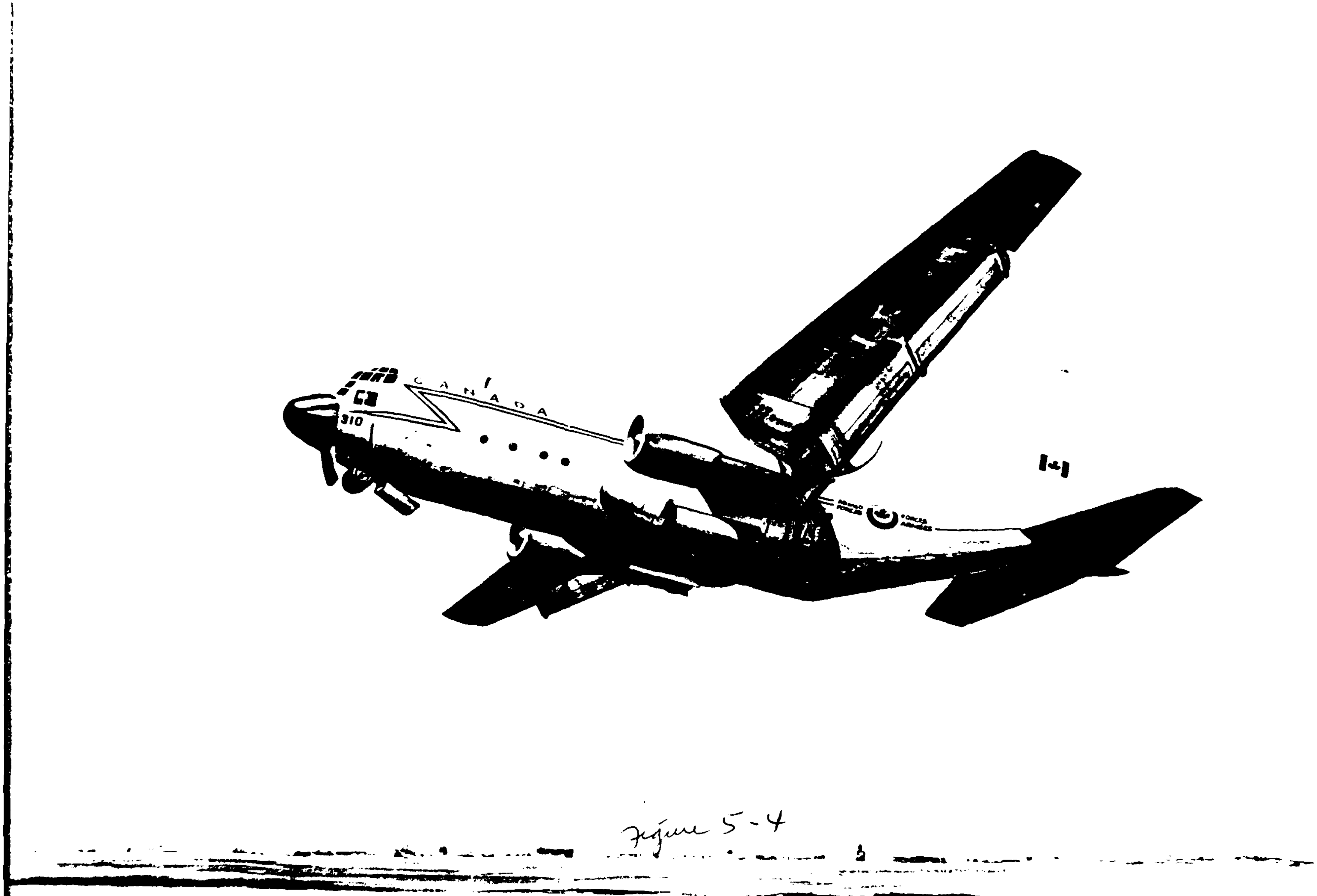


Figure 5-4

CHAPTER VI

FUTURE DEVELOPMENTAL AND PRODUCTION PROGRAMS

> "To meet our airlift objectives, we must improve our existing airlift forces as well as acquire additional lift capacity."[1]

C-130 RETROFIT & PRODUCTION PROGRAMS

Secretary Weinberger's guidance has profound implications when considering the quantum operational and economic benefits which could accrue from the application of Augmentor Wing (AW) technology. The demonstrator program discussed at Chapter V could be viewed as a decision node leading to optional means of producing operational variants. One branch would lead to program termination if the technology or other factors precluded development. One branch would lead to a program to retrofit operational C-130s. One branch would lead to a program to manufacture Augmentor Wing C-130s from the ground up on the assembly line at Lockheed-Georgia. One branch would lead to an Advanced Tactical Transport. Any decision to proceed could, in time, lead to each of the other programs becoming economically and operationally viable. For now let us consider the production line version of the Augmentor Wing C-130 referred to as the "C-130 PL" by De Havilland.

PREDICTED PRODUCTION RUN CONVERSION COSTS

Cost data for a production run of the PW2037 powered version of the C-130 PL will be considered representative of the RB419 variant. Similarly, the cost of a retrofit conversion and a production line C-130 PL, or Transall, will be considered to be the same. While this approach may oversimplify cost and timing

PAYLOAD - RANGE

FOR

C-130PL WITH TWO PW2037 3-STREAM DERIVATIVE ENGINES COMPARED WITH STANDARD C-130H

LATEST TACTICAL ASSAULT AIRLIFTER EQUIPMENT ADDED

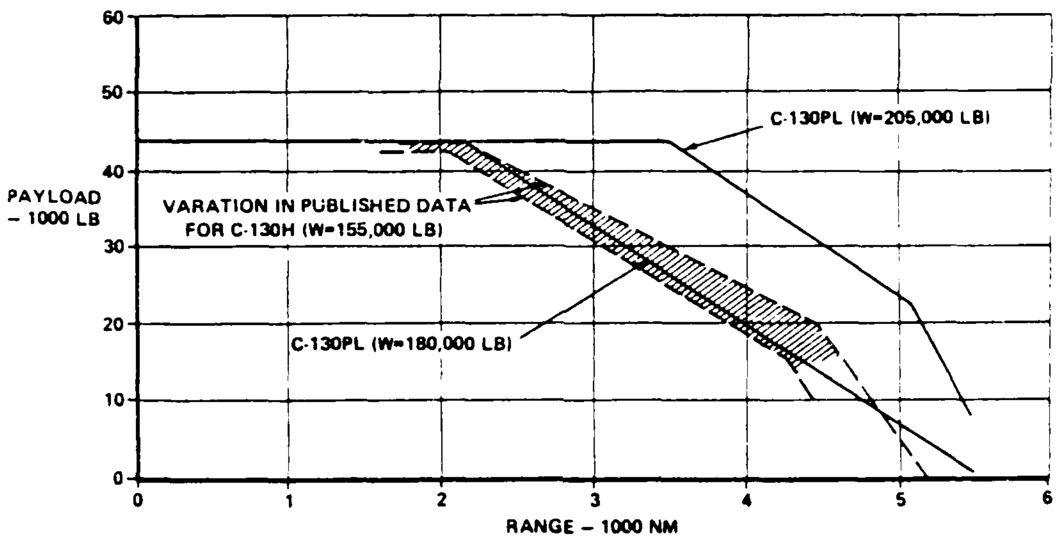


FIGURE 6-1

C-130PL 2 PW2037 3-STREAM
DERIVATIVE ENGINES
TAKEOFF PERFORMANCE

WING AREA 1745 SQ.FT.
SEA LEVEL D.I.G.V. 20°

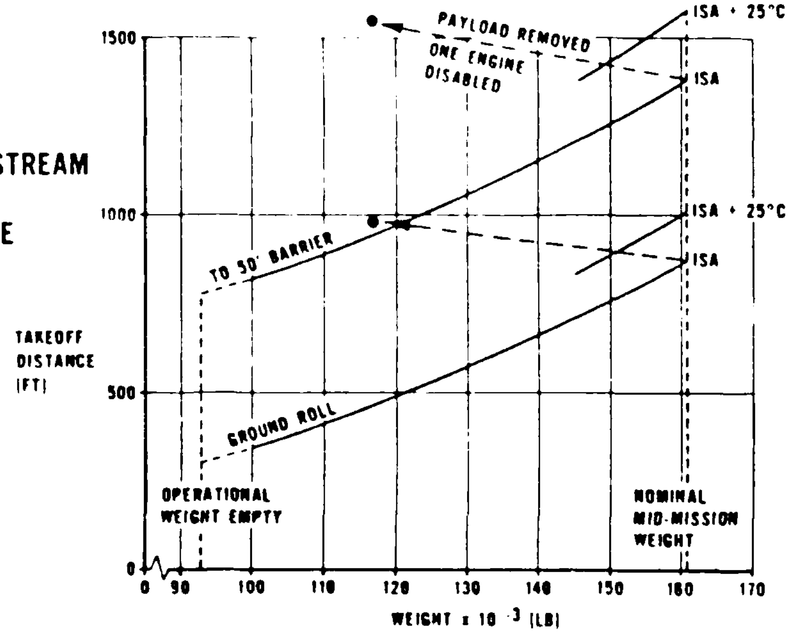


FIGURE 6-2

C-130PL WITH PW 3-STREAM DERIVATIVE ENGINE
LIFT-OFF SPEEDS

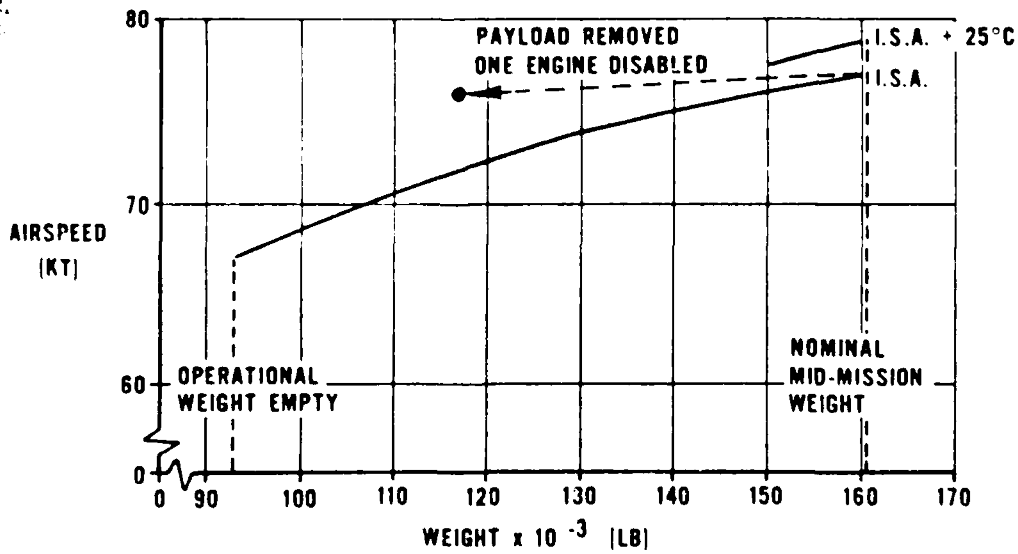
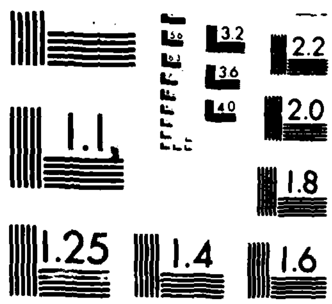


FIGURE 6-3

AD-A177 758 AUGMENTOR WING POWERED LIFT TECHNOLOGY: AFFORDABLE 2/2
ALTERNATIVES TO ENHANCE TACTICAL AIRLIFT CAPABILITY(U)
AIR WAR COLL MAXWELL AFB AL J E MCGEE MAY 86
UNCLASSIFIED AU-AWC-86-143 F/G 1/3 NL


3.2
3.6
4.0
2.2
2.0
1.1
1.8
1.25
1.4
1.6

considerations, there should be reasonable confidence in the estimates given.

Following completion of the Phase C Demonstrator program a Full Scale Development (FSD) through Federal Aviation Agency (FAA) Certification of the PW2037 will take 42 months and cost $200M (1986 US). Delivery of production engines could begin three months after FAA Certification. The predicted costs of converting C-130s to the augmentor wing and engines, in production runs of 50 to 300, are shown below.

PREDICTED CONVERSION COST TABLE ($M U.S 1986).

# OF A/C	50	100	150	300	
AIRFRAME	6.0	4.9	4.6	4.5	
ENGINES	8.2	8.0	7.9	7.7	
TOTAL	$14.2M	$12.9M	$12.5M	$12.2M	per aircraft.

Of the 1800-plus C-130s which have been built, the ". . . "A" models will be able to remain in service through the mid-1990s, and the later models into the next century."[2] Not all 1800 remain in service and more will have been retired by the time a production engine could be developed. There is a saying that the only replacement for a C-130 is a new C-130, thus it is likely that the numbers of operational C-130s will not diminish much below current levels. Observing also that the RFP initially calls up only 300 new tactical airlifters (of the 518 identified by Secretary of Defense in the tactical airlift role): the remainder are Augmentor Wing retrofit modification candidates. In this era of exceptional fiscal constraint, conversion may be the only possible means of getting significant operational improvements into the tactical airlift and special operations fleets. Certainly, for a variety of reasons, some

C-130 PL LANDING PERFORMANCE

TWO PW THREE-STREAM ENGINES

ISA SL

4.5° APPROACH — *NO FLARE*

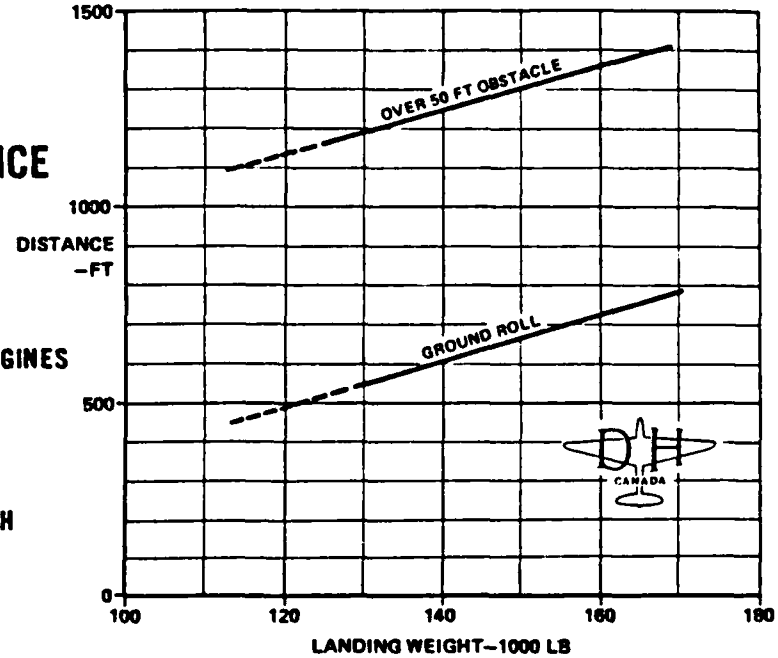


FIGURE 6-4

C-130 WITH 2 PW2037 3-STREAM DERIVATIVE ENGINES LANDING THRESHOLD SPEEDS COMPARED WITH STANDARD C-130H

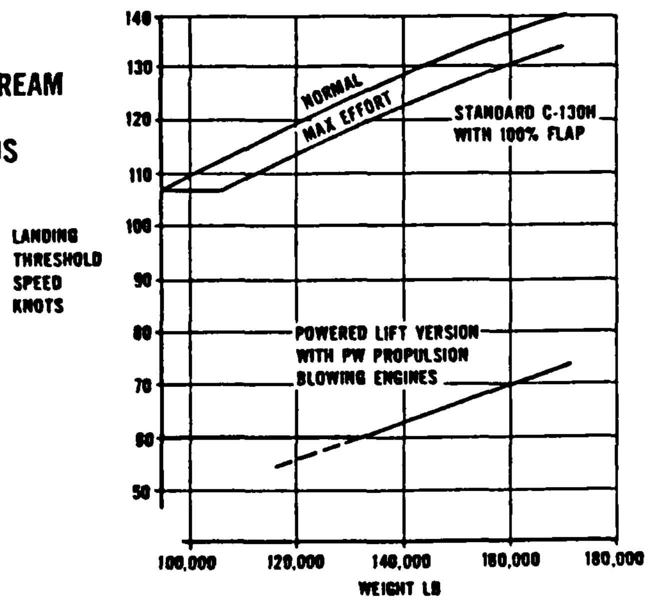


FIGURE 6-5

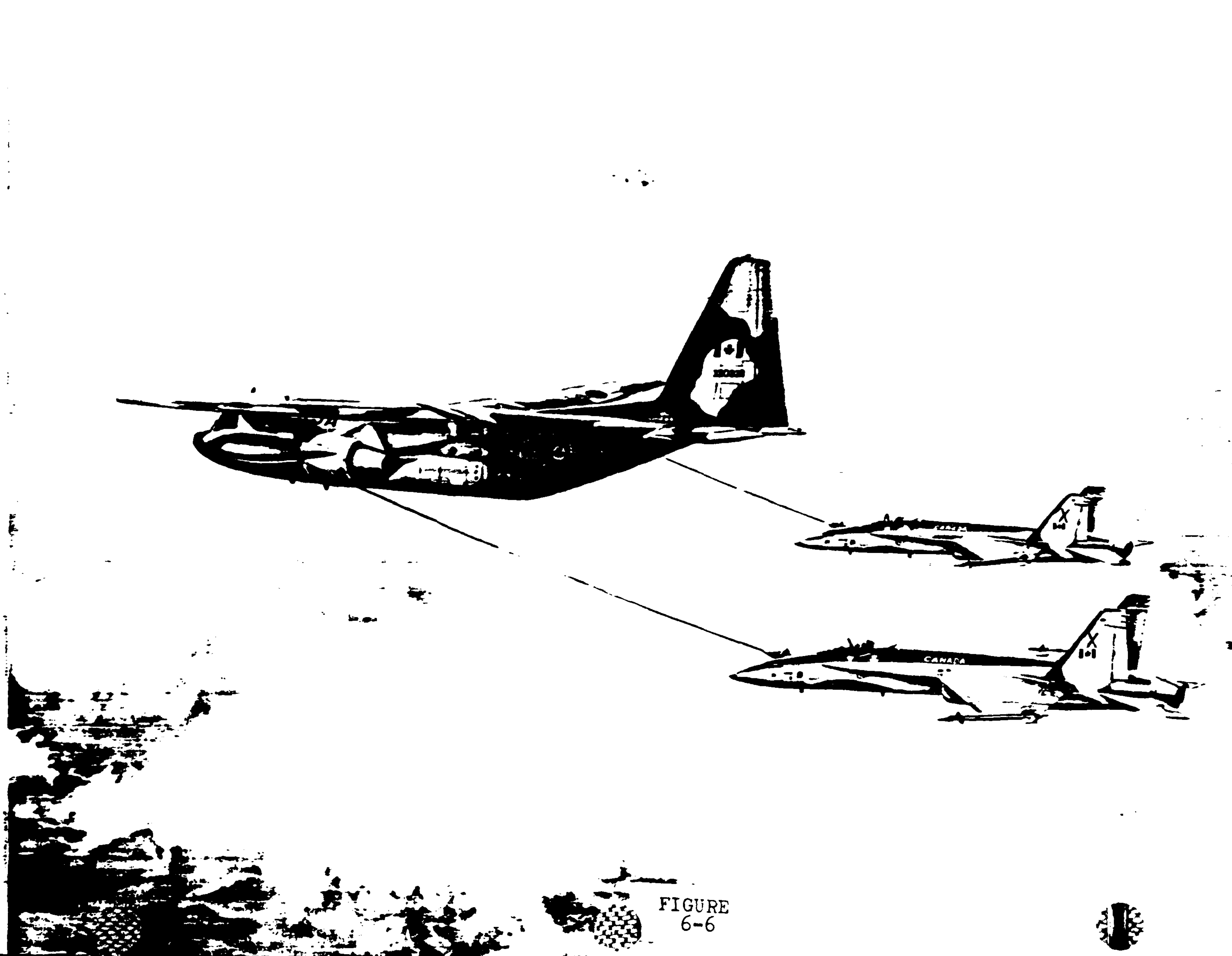


FIGURE
6-6

KC-130PL

TANKER VERSION

TWO MODIFIED PW TURBOFANS

WING AREA = 1745 SQ FT

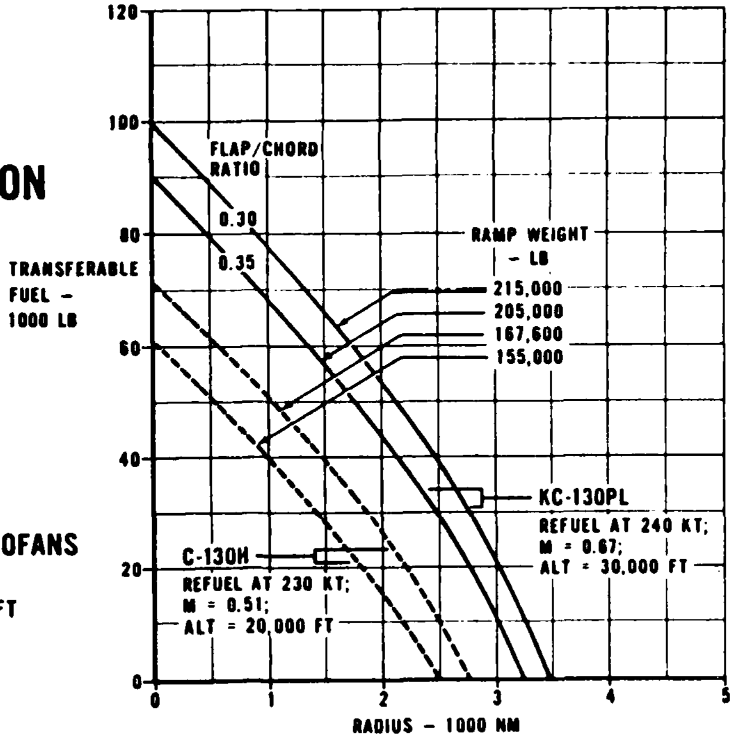
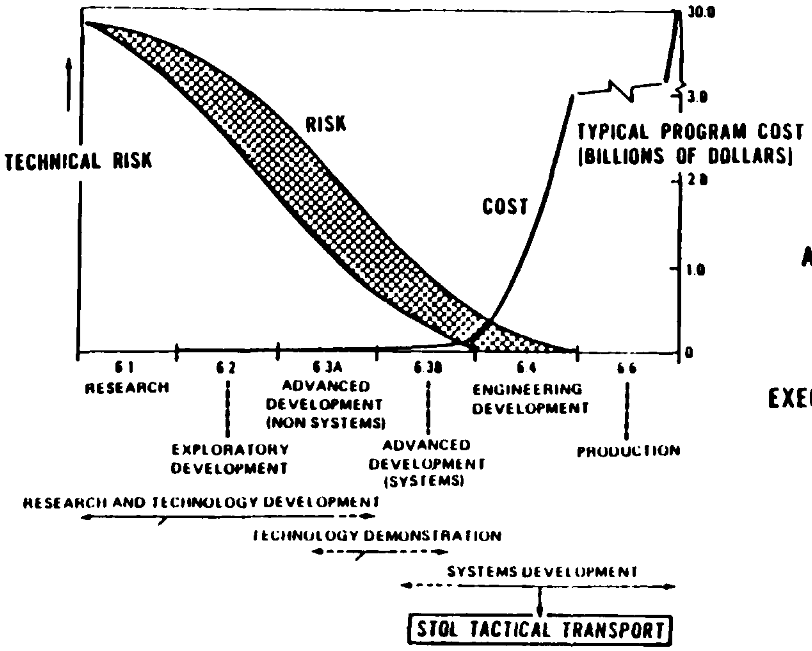


FIGURE 6-7

RISK/COST PROFILE FOR SYSTEMS DEVELOPMENT



REFERENCE

AERONAUTICAL RESEARCH AND TECHNOLOGY POLICY

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY

November 1982

 FIGURE 6-8

CHAPTER VII

FIGHTER AND PILOT TRAINER DEVELOPMENT

The thesis of this paper is, primarily, to show the benefits of augmentor wing technology to the development of new military airlifters. But the technology has other applications: a brief examination of which will afford the reader a more thorough understanding of the versatility of the technology, and the extent of the research and development work which has been initiated by De Havilland Canada and supported by Canadian and United States government agencies. Specifically, analytical and experimental studies of Supersonic Short Take Off Vertical Land (SSTOVL) Fighters and transonic pilot trainers will be briefly reported on in this chapter.

SUPERSONIC SHORT TAKE-OFF VERTICAL LAND (SSTOVL) FIGHTER DEVELOPMENT.

On October 22, 1985 the United States' National Aeronautics and Space Administration (NASA) and the Canadian Department of Regional Industrial Expansion (DRIE) signed a cooperative agreement for an Ejector Lift/Vectored Thrust (EL/VT) aircraft research project. This is the latest in a series of agreements between NASA Ames and the Canadian Government [Department of National Defence (DND), and DRIE] spanning a decade of joint research and wind-tunnel testing of half-scale models of generic Short Take-Off Vertical Land (STOVL) fighter aircraft. De Havilland Aircraft of Canada Limited (DHC) is responsible for the research which is a natural extension of their earlier work.

De Havilland will develop the concept, manufacture the model and integrate the powerplant and lift system into it. NASA will then complete phase one with static tests at a new NASA Lewis facility using a remote air supply. Phase two will involve fitting a standard jet engine to the model for static and wind-tunnel tests in the Full Scale Aerodynamics Complex at the NASA Ames Research Center. NASA has given this project a high priority in its examination of Advanced STOVL technologies scheduled for completion in 1988.

De Havilland has developed expertise in fixed wing aircraft hovering and in transition to conventional forward flight at speeds up to 150 knots. For the synthesis of their STOVL technology with high performance transonic and supersonic technology they have collaborated with the United States aircraft industry. General Dynamics E-7 [Figure 7-1] concept uses De Havilland EL/VT technology[1] and De Havilland continues to work with NASA and General Dynamics.

THE OPERATIONAL UTILITY OF SHORT TAKE OFF/VERTICAL LAND (STOVL)

The utility of STOVL was proven by the Harrier during the 1982 Falklands Conflict. The inherent design characteristics needed for STOVL in a fixed-wing aircraft, such as Vectoring in Forward Flight ("VIFFing") translate into high combat agility. Most of the engagements between combatants were at high speed (550Kts) and at low level (between 50 and 500 feet above the terrain or the sea).[2] High G and rapid acceleration/deceleration manoeuvres in this essentially horizontal plane opened a new chapter on aerial combat tactics.

Tactical agility is a powerful bonus to the current main motivation behind the development of STOVL fighters: off-base operations. The elimination of the conventional dependency on inherently vulnerable runways,[3] and launching or recovery aids enhances the flexitility of air operations and increases force survivabilty.[4] STOVL aircraft can be quickly and economically repositioned, concealed from attack, or launched against the threat. With thrust to weight ratios of 1:1, Harrier experience has shown that vertical take-off is most frequently used for repositioning aircraft at lighter weights, and short take-off (1200' ground roll) is preferred for combat weights. A supersonic fighter would likely be employed in the same way: short take-off and vertical land.

Short take-off is not a critical problem for most Conventional Take Off and Land (CTOL) fighters; however, the high energy levels make short field landings difficult. Vertical landing capability greatly increases the likelihood of recovering aircraft when airfields are denied due to combat or weather. Where runways have sustained damage, the flexibility of short/vertical take-off and landing permit air operations when they would otherwise be impossible. In NATO Europe this could be a crucial factor. Extremely slow speed approaches to vertical landings increase the likelihood of safe aircraft recovery regardless of weather conditions. A direct operational benefit is a reduction in fuel margins leaving more fuel for combat. Other benefits include, independence of wind direction and runway friction, omni-directional non-precision approaches, and the STOVL aircraft can slow down and/or stop in flight if required.[5]

The reinforcement of central Europe by tactical fighters will very likely tax the ability of host bases to accommodate them and to provide for their security under attack. As reported by Michael Gordon, base availability was of fundamental concern in that segment of the Long Term Defense Plan which dealt with United States reinforcement of Europe. The 1,500 committed aircraft could not be accommodated at the 25 U.S. airfields. The plan to disperse them over more than 70 Co-located Operating Bases (COBs) has tactical and protective value. It also has associated cost: The fiscal cost of shelters for the aircraft and the tactical cost of dependency on those airfields for not only support but survivability.[6] STOVL aircraft which are more readily camouflaged and hidden off base have inherent survival capability not found in conventional aircraft. Moreover, European weather and airspace saturation pose additional threats to the timely deployment of rapid reactor and reinforcement aircraft from North America. STOVL aircraft capable of very slow or vertical approaches are more likely to arrive at planned destinations on time.

Off-base operations permit supporting the army with aircraft just a few miles (18-20) behind the lines. The resultant enhanced reaction time and target selection increase the effectiveness of close air support.

Sea-borne operations are similarly enhanced. STOVL permits safer operations from smaller, less complicated ships in weather and sea states which would preclude conventional carrier aircraft operations.[7] However, STOVL of itself does not restrict or limit the size of ship. Indeed, it enhances large carrier operations. For example, STOVL also affords naval architects the flexibility of designing more combat effectiveness into the largest of nuclear attack carriers by replacing the space used for arrestor gear and catapaults with fuel and ammunition, and freeing more of the flight deck for aircraft, additional squadrons can be embarked.

ADVANCED TACTICAL FIGHTER (ATF) REQUIREMENTS

While little specific data will be listed here on individual fighter requirements, all nations are seeking greater agility for air fighting and threat avoidance, longer range and more survivability. Larger and more sophisticated electronics countermeasures packages and improved weapons payloads will be expected.

USAF sponsored research for improvements in F-15s and F-16s suggest the next (advanced) fighter will be highly manoeuverable, with 2-D vectoring nozzles a la F-15 STOL, have at least twice the tactical range of the F-15 (with a transatlantic ferry range), and will likely be twin engined aircraft capable of supersonic flight (M 1.5) in basic engine. Field performance will mark a major change: takeoffs and landings in 2,000 feet field length for continued operations from bombed runways. (De Havilland studies show their supersonic fighter to be capable of a take-off ground roll of 500 feet or less at mission weights, and vertical landing. Vertical take-off would also be possible at lighter weights.)

FUTURE DE HAVILLAND EJECTOR LIFT/VECTORED THRUST (EL/VT) TECHNOLOGY

De Havilland and NASA will be conducting wind tunnel tests and flight simulation trials of the General Dynamics/De Havilland E-7 configuration. The Canadian Department of National Defence (DND) is funding a program to design and build a 1/4 scale model of an SSTOVL for test in the National Aeronautics Establishment (NAE) 30 x 30 ft. tunnel in Ottawa. DND and NASA are also cooperating on low speed testing of an existing large scale model [Figure 7-2]. Data from these tests will be used in the full scale test being jointly funded by the Canadian Department of Regional Industrial Expansion (DRIE) and NASA. Results of the full scale testing in the NASA 80 x 120 ft. wind tunnel will provide aerodynamic and stability derivative data for flight simulation. This will then lead to trials "using the large-scale moving base flight simulation facilities at the NASA Ames Research Center."[8]

ADVANCED SHORT TAKE OFF VERTICAL LANDING (ASTOVL) COMBAT AIRCRAFT

This joint work with NASA is aimed towards the selection of a technology configuration for the Advanced Short Takeoff Vertical Land (ASTOVL) combat aircraft program. Its objective is to seek a replacement for the AV8B Harrier in the UK and U.S. inventories. "In Britain, ASTOVL is seen as the follow-on to the . . . Sea Harrier. In the USA, ASTOVL would be timed to follow the Advanced Tactical Fighter (ATF) as the F-16 followed the F-15. While the ATF is several years behind the European program, the ATF and ASTOVL schedules would probably overlap . . ."[9] Since the foundation already exists for a joint US/UK ASTOVL cooperative program, the US/Canadian collaboration provides the opportunity to broaden its base. Particularly if the EL/VT technology is chosen for ASTOVL, it would be a powerful incentive for DND to participate in a reasonably large production run and rebuild its fighter force.

ADVANCED TRAINER EMPLOYING EJECTOR LIFT/VECTORED THRUST (EL/VT)

The Canadian Forces (CF) have expressed interest in an EL/VT advanced trainer for pilots in the undergraduate and postgraduate fighter training stream. With the retirement of the last of the CF century series fighters, planning is in progress to optimize the training towards the CF-18A. The new advanced trainer should be highly agile, accustom pilots to the rapid onset of G, have an inherent weapons capability, and land in the same speed range as the CF-18 (125 Kts). Whereas CF basic pilot training is conducted side-by-side, the advanced trainer should have tandem seating [Figure 7-3]. A simplified, unarmed version of the aircraft would be used for undergraduate training. An armed version would be used for postgraduate training. The aircraft would be capable of in-flight refuelling.

Advanced manoevering and aircraft trim authority from the powered lift system would be realized from the takeoff rotation through landing. Direct Lift Control (DCL) systems examined included the F-111 Advanced Fighter Technology Integration (AFTI), F-15 Agile Eagle, F-16 manoeuvering flaps to increase wing camber, and the AV-8B Harrier Vectoring in Forward Flight (VIFFing). Direct Drag Control (DDC) to give the pilot full control over acceleration and deceleration was also examined. In addition to the conventional means of deceleration thrust reversal (Agile Eagle), pylon split flap (Alpha Jet) and, again, VIFFing were evaluated. Direct Side Force Control provides new manoeuvres such as lateral translation or "sidestep" (yaw pointing), and the Wings Level Turn (WLT) or Flat Turn manoeuvre with minimal sideslip (which virtually eliminates the tendency for a rolling moment to be developed). Agility from any or all of these concepts would be valuable for target acquisition and/or evasion. The landing approach configuration would have a much reduced approach speed for a given weight and wing area, yet go-around performance is greatly improved.

The study aircraft would be capable of supersonic operations longer than the CF-5D, for example, since it would reach M 1.2 in basic engine. At a sustained manoevering speed of M 1.4, fuel consumption would be less than 70 percent of the F-5.

This initial work holds promise for an advanced trainer which would prepare pilots to fly and fight the modern agile fighters which will be in-service at the turn of the century.

SUMMARY

This brief review of fighter and trainer technology was to show the depth of the De Havilland research on augmentor and ejector technology and to reaffirm that the " . . . family of ejector concepts [is] based on original research by de Havilland Canada, and indirectly traceable to DHC's Augmentor Wing Buffalo test aircraft."[10] It has also shown the agility and survivability of a SSTOVL fighter which has the flexibility of operating from minimally prepared short surfaces.

> "It is vital to remember here that we are describing a 'survival to operate' capability."[11]

British Aerospace has taken a commanding lead in the development of STOVL. The Harrier has proven itself and the concept in combat. Ironically, large sums are being spent to develop agile versions of conventional combat aircraft when the Harrier has already led the way in flight agility. The next threshold for STOVL is the attainment of supersonic speeds. The De Havilland Ejector Lift technology combined with British Aerospace's Vectored Thrust appears to be a logical synthesis of two powerful concepts which should be part of ATF and A/STOVL.

NOTES

CHAPTER VII

[1]D.C. Whittley and P.R. Sully. "Recent Canadian Developments in Powered Lift Technology," reporting to the 1985 Defence Science Symposium, Department of National Defence, Ottawa, Ontario, Canada, November 19-20, 1985; Sweetman, Infra, p. 1327; and as reported in Aviation Week coverage of the E-7.

[2]V/STOL in the Roaring Forties: 75 Days in the South Atlantic. (Surrey, England: British Aerospace PLC, 1982), p. 36.

[3]Captain J.D. Williams, CF. "The Need For Dispersal of Canadian Tactical Air Forces," Canadian Defence Quarterly/Revue Canadienne de Defense, 14(3), (Winter 1984/85 Hiver December 1984 Decembre), 36-40.

[4]J.W. Fozard, Tactical Jet V/STOL - its future in a CTOL world: Lessons from a quarter-century of evolutionary revolution, (Surrey, UK: Dr. J.W. Fozard and British Aerospace, July, 1985), p. 33.

[5]Lieutenant Colonel Price T. Bingham. "Air Base Survivability and V/STOL Aircraft: a Gap in Air Force Doctrine," Air War College Review, XXXVII(2), (January-February 1986), 52.

[6]Michael R. Gordon. "NATO: Some is Better than "Nunn," Military Logistics Forum. March, 1985, p. 22.

[7]cf. Roaring Forties, pp. 16,24., and Jeff Ethell, "The Makeshift War," Military Logistics Forum, March, 1985, p.50.

[8]Whittley and Sully, p. 9.

[9]Bill Sweetman. "From AV-8B to the ASTOVL," Interavia, 12 (1984), 1324.

[10]Sweetman, p. 1327.

[11]Williams, 40.

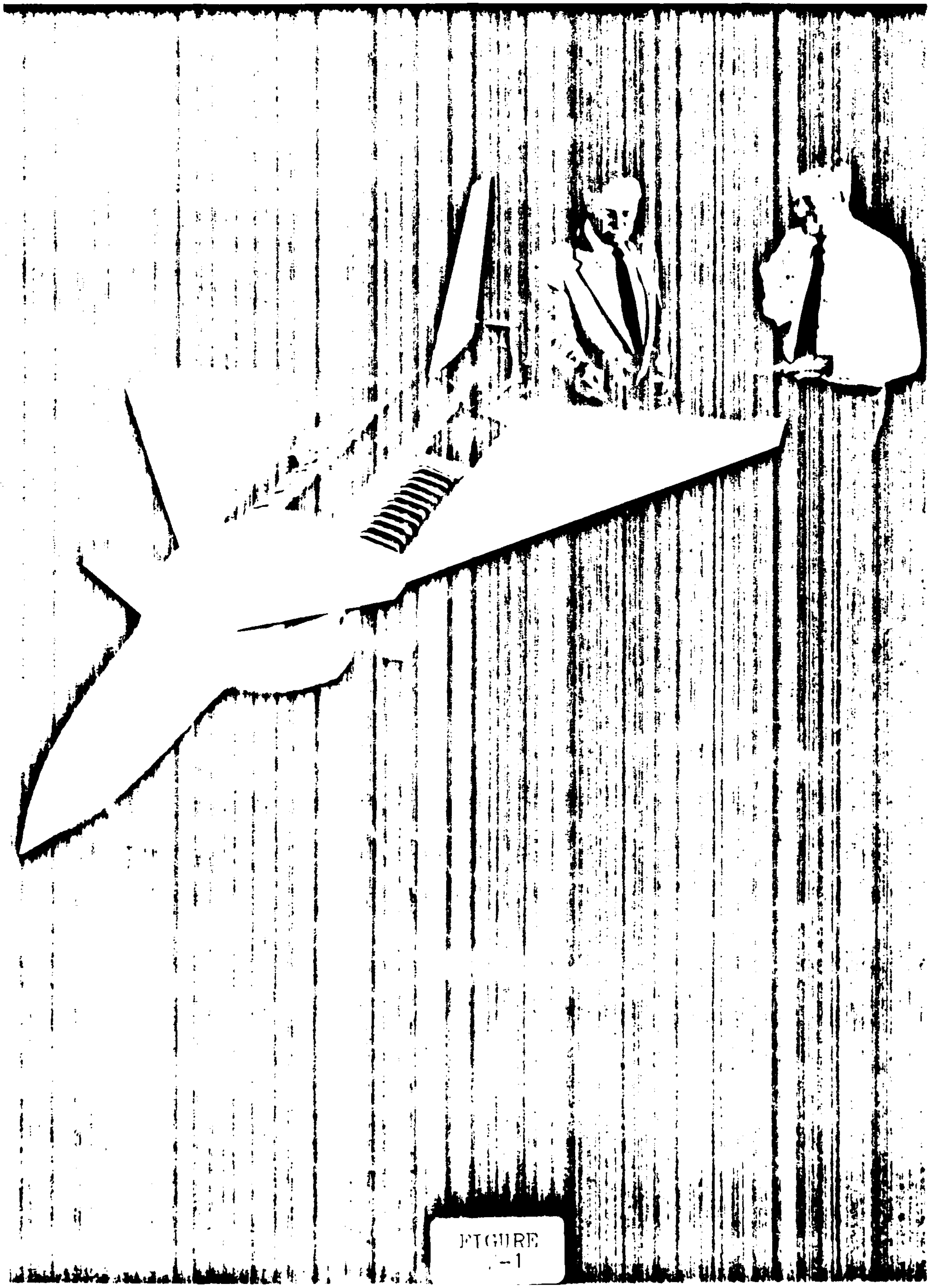
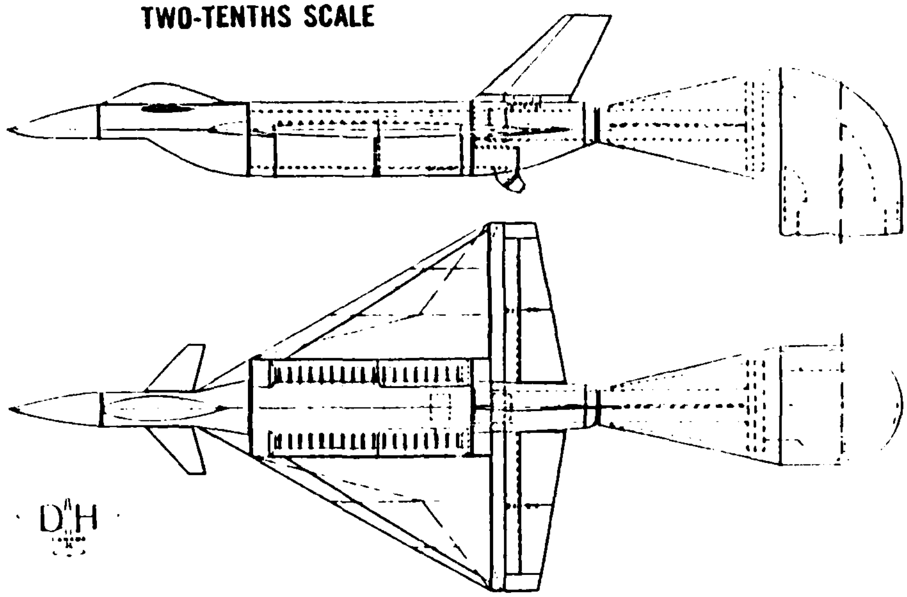


FIGURE
-1

STOVL SUPERSONIC FIGHTER MODEL

TWO-TENTHS SCALE



LARGE SCALE SPEY MODEL EL/VT CONFIGURATION

WITH CANARD CONTROL AND BLC FLAPS

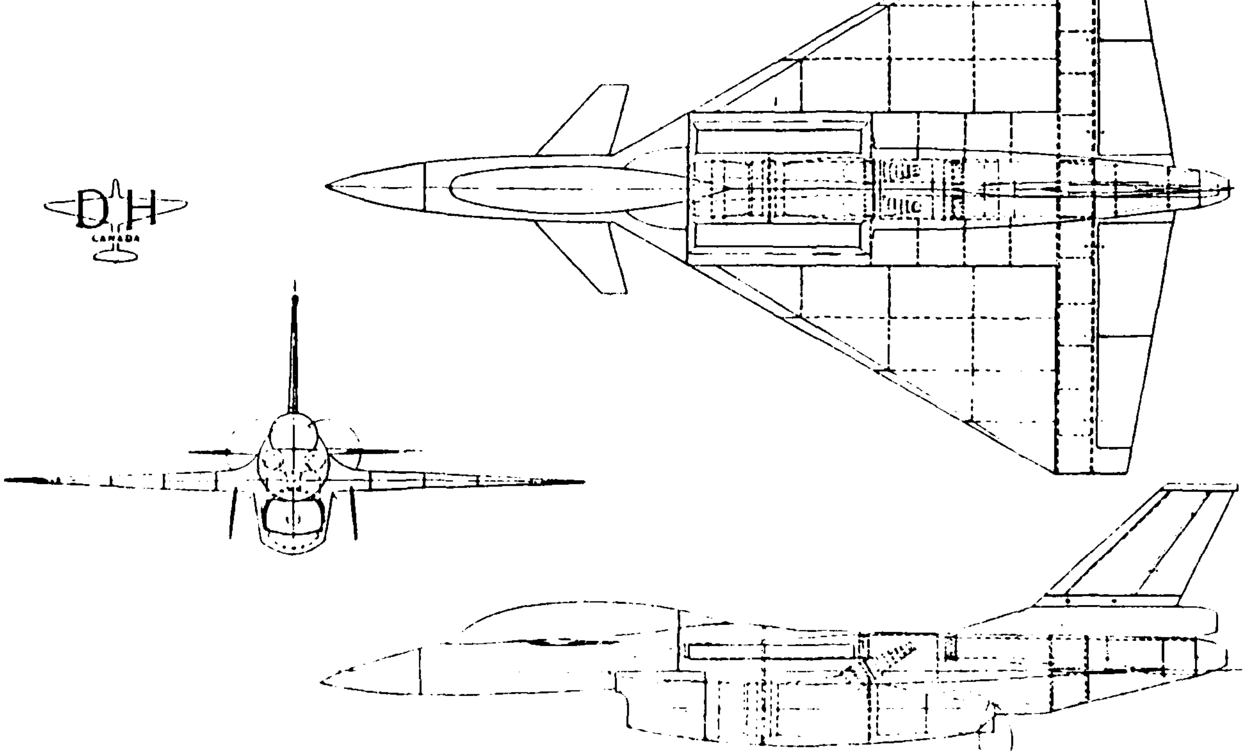


FIGURE [illegible]-2

GENERIC FORM OF ADVANCED TRAINER - VARIANT I

THRUST VECTORING IN FORWARD FLIGHT (VIFF) WITH RE-HEAT OF BYPASS FLOW

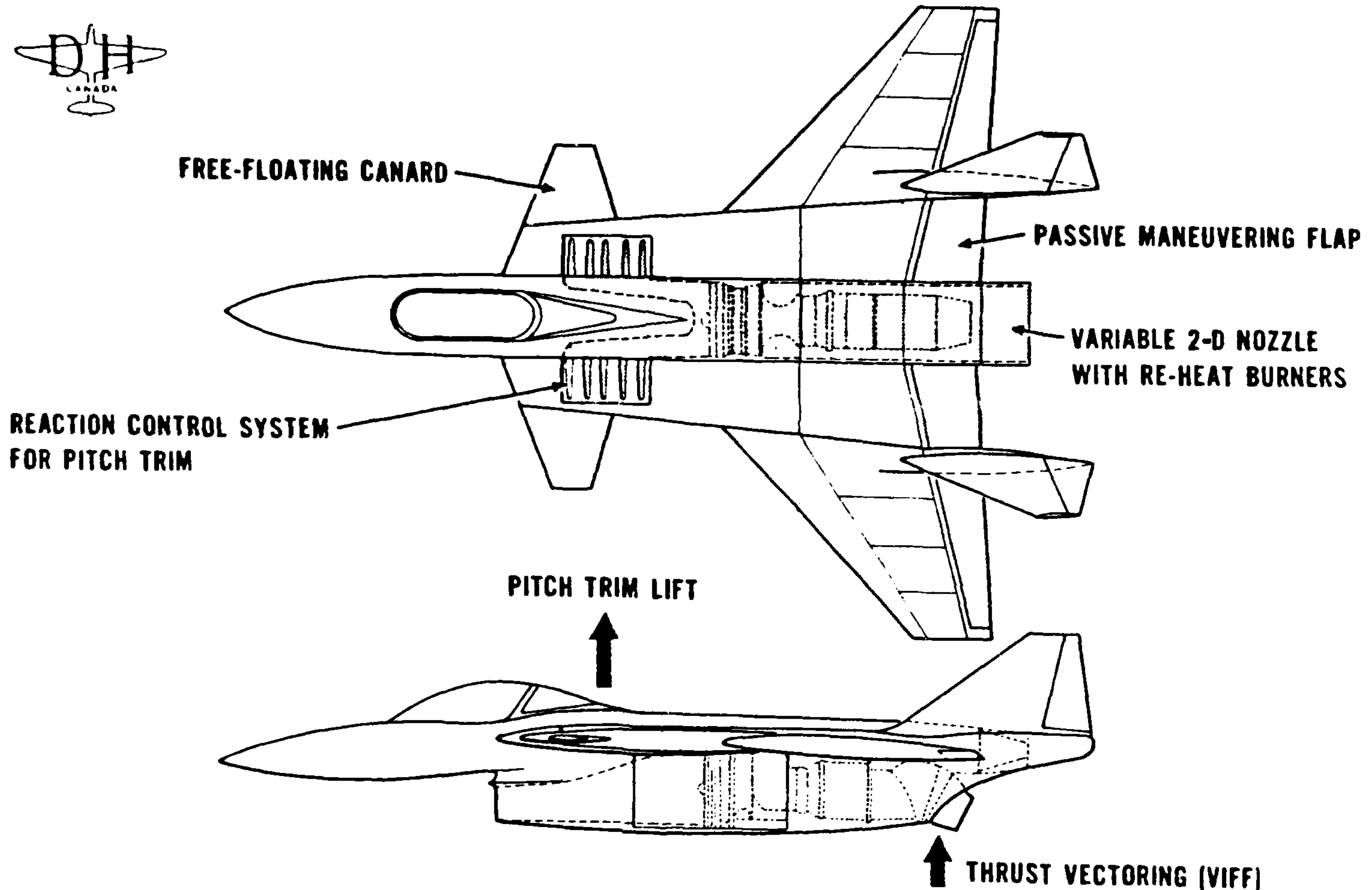


FIGURE 7-3

CHAPTER VIII

CONCLUSIONS

"Air power is becoming increasingly expensive, and if these costs are not to impose a crippling limitation on the development of future weapons systems they must be balanced by corresponding improvements in effectiveness.[1]

When those words were written a year and a half ago, the author was contemplating the rising cost of aerospace products where inflation had outpaced other commodities by significant margins. The resulting high costs were impacting defense budgets. Since then, the United States defense budget has been threatened by domestic fiscal reality through a congressional act given the name of its three drafters: Gramm-Rudmann-Hollings. Now, bold and imaginative steps are needed to continue force modernization. One means of stretching out the available development dollars is to enter into joint research, development and production programs. This paper has discussed the Canadian proposal for a 50/50 cost sharing in an Advanced Tactical Transport (ATT) demonstrator aircraft program using the Augmentor Wing technology, and interest in the shared development and production of the Advanced Tactical Transport itself. Capitalizing on other current U.S./Canada joint research projects in Ejector Lift/Vectored Thrust (EL/VT) technology could result in U.S./Canada development and production of the Advanced Tactical Fighter (ATF), Advanced/Short Take Off Vertical Land (A/STOVL) aircraft, and an advanced pilot trainer. There are compelling operational reasons to upgrade this research into production programs. Now, there are compelling budgetary and programmatic reasons.

AUGMENTOR WING TECHNOLOGY MEETS OR EXCEEDS ALLIED AIR FORCE REQUIREMENTS

This paper started out to show the advantages of using the De Havilland Canada (DHC) Augmentor Wing (AW) technology in tactical airlifters as an affordable means of satisfying the requirements which a number of western air forces envisage at the end of the century. The specifications being called up by the major users of tactical airlifters essentially reflect incremental improvements to the C-130. The AW technology alternatives reviewed here have met or exceeded the performance criteria in all cases, and are consistent with the USAF Request For Proposal (RFP) which calls for a twin-engined Advanced Tactical Transport (ATT). The British, West German and French industries which have teamed with Lockheed-Georgia to propose a Future International Military Airlifter (FIMA) may require a three-engine, wide-body cargo configuration, and De Havilland has conducted parametric studies showing the benefits of the AW technology to a 3-engined FIMA.

Perhaps the main advantage of the Augmentor Wing technology is its inherent adaptability. It is universally applicable to turboprop or turbofan powered aircraft using 2, 3 or 4 engines and ranging in size from approximately 50,000 to 500,000 pounds Design Gross Weight. Wherever aircraft require high subsonic cruise speeds, yet must operate from short fields, and where operators want safe and easily controllable approaches, landings, go-arounds and takeoffs when the critical engine has failed, the Augmentor Wing technology should be factored into the design.

OPERATIONAL ADVANTAGES

Payload/range and speed flexibility of an Augmentor Wing aircraft which has virtually no Minimum Control Speed Air (V_{MCA}) opens new possibilities for air land and air drop delivery. LAPES at 65-80 knots would improve accuracy and the condition of the load upon arrival, and the quick response to throttle movement would facilitate a high rate of climb, high speed egress from the low level threat environment. Requiring only a 1000 foot ground roll (500 feet at lighter weights), there are vastly more airfields open to the AW airlifter, increasing the probability of operating in closer proximity to the Forward Line of Own Troops (FLOT) and lessening dependency on staging bases. This all translates into greater reliability of delivery and greater productivity.

SPECIAL OPERATIONS

The thick wing affords greater flexibility in offsetting payload with fuel for longer range penetrations with small patrols or light tactical loads. Excellent low level, slow speed maneuvering and high dash speed combine with a relatively low radar cross-section to aid in avoiding detection and enhance evasion.

SEARCH AND RESCUE (SAR)

In SAR the combination of high dash speed, long range, and uncompromised slow speed stability and long endurance inherent in an AW aircraft enhance its effectiveness as a search platform. The potential for developmental extension of the flight regime to include vertical takeoffs and landings and effect immediate rescue upon detection of a survivor would complement the other AW attributes to make it the complete search and rescue vehicle whether in peacetime or in combat.

AUGMENTOR WING TANKER

The thick supercritical wing of the AW modifed C-130 provides for substantial fuel capacity in the wing box, supplemented by a 23,000lb. fuselage tank in the tanker version. Thus, the "KC-130 PL" has greater flexibility of speed, altitude and ranges to refuel recipient aircraft in their optimum cruise envelope. The Augmentor Wing airlifter as an in-flight refueller, then, is the essence of a force multiplier and all tactical airlifters should be capable of taking on or giving fuel.

C-130 AUGMENTOR WING DEMONSTRATOR

The Canadian Government will sponsor a demonstrator program on a 50/50 basis. Because the technology is mature and development would have low economic, technical and operational risk, the pure AW technology "demonstrator" phase could be bypassed in favor of building production aircraft: the first of which would be the flight test article. This would accelerate the Initial Operational Capability (IOC) date and further enhance system affordability. In this eventuality, the demonstrator program could be initiated in parallel to extend the technology into VSTOL or VTOL. This would be a preferred outcome; however, if it is not intended to initiate a production program in the near term, a demonstrator program should be pursued immediately.

C-130 PL RETROFIT OR ASSEMBLY LINE PRODUCTION

Of the large number of C-130s serving in western air forces, a reasonable number will have to undergo wing replacement modifications in order to extend service life. Other C-130s are operated by air forces which have special operational requirements which could be satisfied by an AW technology variant. Such inventory C-130s are candidates for a retrofit program. Likewise, some countries are trying to increase the size and capability of their air forces in the face of constrained budgets. The availability of a production line AW capable C-130 PL for a reasonable price increment would provide an attractive vehicle with which to enhance force airlift. As a less costly option to an all-new design, a production conversion C-130 PL would have spin-off benefits in the foreign military aid budget.

ADVANCED TACTICAL TRANSPORT (ATT)

Looking ahead to an all-new tactical airlifter with systems designed for the operational environment of the next century, the AW technology provides the flight characteristics appropriate to that era. A comparison of the ATT RFP with the AW performance specifications of the C-130 PL vividly demonstrate the advantages of AW technology.

SPECIFICATIONS	RFP	C-130 PL
SIZE	C-130	C-130
WING AREA	1,700-3,135 sq ft.	1,745 sq ft.
ASPECT RATIO	6.34-8	12
THICKNESS/CHORD RATIO	12-14	24
PAYLOAD	44,000LBS	44,000LBS
Note: the C-130 PL carries an integral		6,200LBS ECM fit
Thus, C-130 PL effective payload is:		(50,200LBS).
COMBAT LOAD	27,000LBS	44,000LBS
DASH SPEED	M 0.7-M 0.85	M 0.8
RANGE WITH 36,000LBS	1600nm	4,000nm

STOL WITH 36,000LBS	1500 feet	<1000 ft grnd roll
STOL <36,000LBS		500ft grnd roll
VTOL	0-300 feet	0 achievable with tilt wing.
ENGINE OUT	10% Reduction OK	Capable of SE T/O.*

*Single Engine take off at mid mission wt.(36,000lbs. payload).

As noted earlier, the RFP specifications listed above combine the features of the two "test" aircraft designs of the Advanced Tactical Transport Technologies (ATTT) study. Even the Augmentor Wing C-130 PL performance predictions exceed by a wide margin the capability being sought in an ATT. A new design ATT optimized for AW technology would realize further improvements in performance and operational effectiveness. While there are a number of potential engine options, depending upon operational and national preference, at this point the performance, reliability, efficiency, growth potential, and logistics commonality with the C-17, of the PW2037 engine suggest that the Pratt & Whitney/De Havilland combination would be a strong technology component of any team jointly developing and producing modified tactical airlifters or Advanced Tactical Transports.

FUTURE LARGE AIRCRAFT

For Future Large Aircraft capable of flying over strategic ranges in the transport, tanker, ASW, and AEW roles, the AW technology extends the cruise and payload/range capability of conventional designs by adding STOL performance virtually without penalty. These high value aircraft would enjoy the additional tactical advantages of enhanced maneuvering, longer endurance through slow speed loiter and the flexibility of operating from shorter airfields and/or runways shortened by bomb damage. The additional margins of safety from slow approach speeds and the elimination of roll or yaw upset in the event of a critical engine failure, would increase the margin of safety and the probability of mission recovery in poor weather, even below conventional minima.

ADVANCED TACTICAL FIGHTER (ATF)
ADVANCED VERTICAL/SHORT TAKEOFF AND LAND COMBAT AIRCRAFT (A/STOVL)
ADVANCED PILOT TRAINER

Joint U.S./Canada research and development work in Ejector Lift/Vectored Thrust (EL/VT) for Supersonic Short Take Off Vertical Land (SSTOVL) has the potential to provide the combat agility, and dispersal needed for fighter effectiveness and survivability in todays air war fighting environment. These same techniques can now be incorporated safely into advanced pilot trainers. Training undergraduate fighter pilots in these essential techniques on a less expensive aircraft prepares them to optimize postgraduate training on the more valuable operational fighters. Collaborative production of these fighters and trainers would enhance the interoperability of NORAD and NATO fighter forces.

JOINT/COALITION PROGRAMS

Secretary Weinberger and Congress have endorsed the principle of multinational weapons systems developments. The effects of Gramm-Rudman-Hollings could be sufficiently far reaching that many needed programs will never materialize as one-nation developments. The infusion of funds, technology and demand for the weapons system by a partner, or partners, correspondingly reduce the liability and risk which the United States would have to shoulder. There is, also, a correlation between the size of defense effort a nation can and will mount and the scientific and engineering contribution and commitment which that nation makes to the development of its own weapons systems. The military, political and economic benefits of such burden sharing would have great appeal within Congress, the Administration and DOD.

Dr. DeLauer levied four criteria by which to assess the validity and worth of joint programs. The application of Augmentor Wing technology to the tactical airlift requirements meets these tests. First, it provides a quantum improvement in operational effectiveness, and the larger production run of a collaborative program further reduces per-unit cost. Second, the co-produced Augmentor Wing technology weapons system fulfills military doctrine. Third, there is great similarity of mission requirement amongst the U.S. services and western air forces. Fourth, it makes eminent sense - particularly since certain U.S. and Canadian aerospace companies and the research communities have achieved low risk, operationally oriented, quality Augmentor Wing technologies which are sufficiently mature to be applied to a range of affordable, practical and operationally effective tactical airlift alternatives.

For the past five years, the President of the United States has spearheaded a major reequipment of the U.S. armed forces. The planned modernization is not complete, and completion is in jeopardy because of budget pressures. The Canadian Government, similarly, has been trying to modernize and increase the Canadian Forces after almost two decades of capability erosion. Fiscal reality is constraining in both countries. Sharing research and development, and realizing the economies of scale of co-producing needed systems are ways of freeing-up a larger proportion of each country's defense budget for weapons systems procurement.

From the preceeding, one can only conclude that a United States/Canada Augmentor Wing technology development and production program would be operationally, economically and politically timely. Since our European NATO allies are now planning the development and deployment of an Advanced Tactical Transport which is virtually identical to the USAF and CF requirements, and which is to be brought into service at the same time, the collaborative effort could be broadened to include North America and Europe.[3] The Advanced Tactical Transport is the right end for program collaboration, the Augmentor Wing technology is the right means to that end.

> "U.S. alliances, treaties and agreements serve not only to define clear lines against aggression. By combining the resources of many nations, collective security arrangements also share the common burden."[2]

NOTES
CHAPTER VIII

[1]John Turner. "Air-to-air refuelling: its contribution to cost-effective air operations," Jane's Defence Weekly, (26 January, 1985), 148.

[2]Caspar W. Weinberger. Annual Report to the Congress: Fiscal Year 1987, 35.

[3]This is not meant to exclude other interested allies such as Australia, for example, but represents a grouping of nations having the largest requirement for an Advanced Tactical Transport and where plans are known to be sufficiently advanced as to foster a collaborative agreement. A spin-off benefit of this collaboration would be a less-expensive end-product for those allies who were not involved in the development and production phases but also require the significant capability upgrade at the lowest possible cost.

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GLOSSARY

AAF	Argentine Air Force
AFTI	Advanced Fighter Technology Integration
ASW	Antisubmarine Warfare
ATF	Advanced Tactical Fighter
ATG	Air Transport Group
A/STOVL	Advanced/Short Take Off Vertical Land
ASD/XRM	Aerospace Systems Division/Requirements Planning Department
AW	Augmentor Wing
CADO	Chief Air Doctrine and Operations
CF	Canadian Forces
COB	Co-located Operating Bases
COD	Carrier On-Board Delivery
COIN	Counterinsurgency
CRAD	Chief Research and Development
DDC	Direct Drag Control
DEA	Department of External Affairs
DLC	Direct Lift Control
DND	Department of National Defence
DOD	Department of Defense
DOT	Department of Transport
DRIE	Department of Regional and Industrial Expansion
EL/VT	Ejector Lift/Vectored Thrust
FAA	Federal Aviation Agency
FIMA	Future International Military Airlifter
FLA	Future Large Aircraft
FOL	Forward Operating Location

FSD	Full Scale Development
FTA	Future Transport Aircraft
IEPG	International European Programme Group
IOC	Initial Operational Capability
LAPES	Low Altitude Parachute Extraction
MAC	Military Airlift Command
MENA	Mission Element Need Analysis
MOG	Maximum number (of aircraft) on the ground.
MP	Maritime Patrol
NAE	National Aeronautics Establishment
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NORAD	North American Aerospace Defense
NRC	National Research Council
RAF	Royal Air Force
RAAF	Royal Australian Air Force
SAR	Search and Rescue
SAWC	Special Air Warfare Center
SOF	Special Operations Force
SON	Statement of Need
SSTOVL	Supersonic Short Take-Off Vertical Land
STOL	Short Take Off and Land
STOVL	Short Take-Off Vertical Land
SWA	South West Asia
TMMA	Tactical Mobility Mission Analysis
U.S.-U.S.A.	United States of America
USA	United States Army
USAF	United States Air Force

USCG	United States Coast Guard
USMC	United States Marine Corps
USN	United States Navy
VIFFing	Vectoring In Forward Flight
VP	Fixed Wing Antisubmarine Patrol Plane
VS	Fixed Wing Carrier-borne Antisubmarine Aircraft
WLT	Wings Level Turn

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